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April 1987

## ***Diving Birds of North America: Species Accounts — Loons*** **(Gaviidae)**

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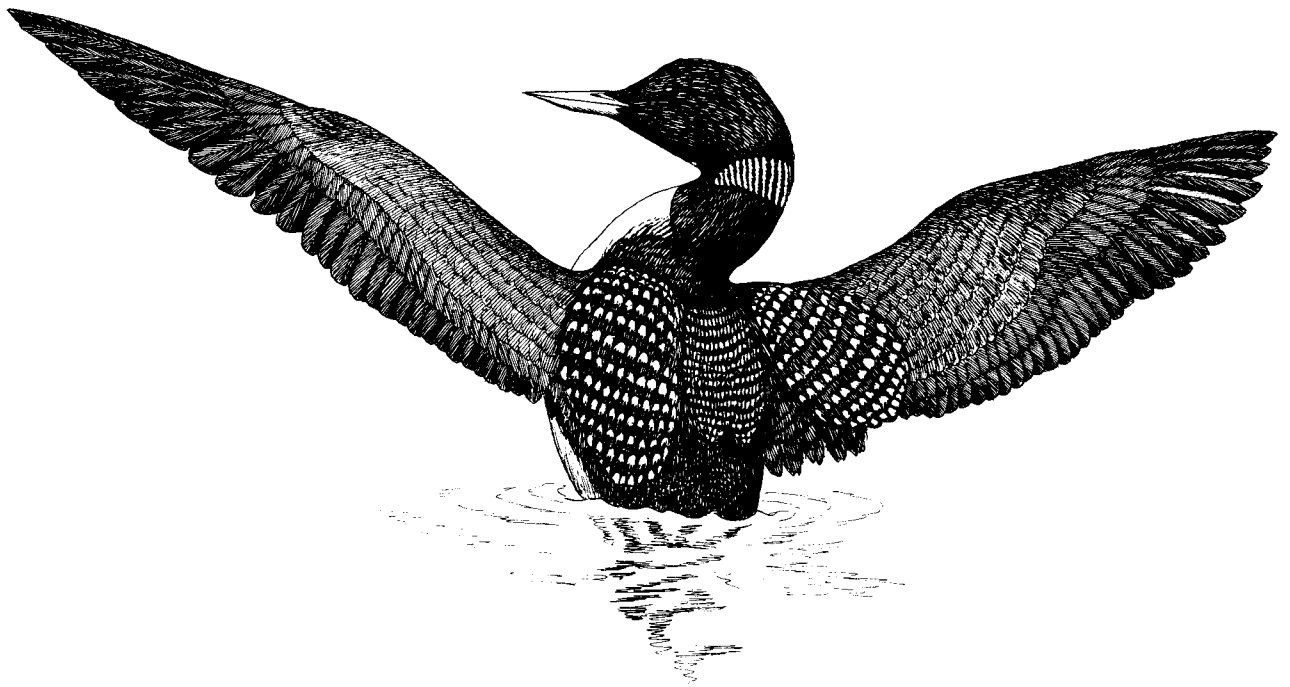
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# Species Accounts

# Loons (*Gaviidae*)





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## Red-throated Loon (Red-throated Diver)

*Gavia stellata* (Pontoppidan)

OTHER VERNACULAR NAMES; Røstrubet lom (Danish); plongeon catmarin (French); Sterntaucher (German); lomur (Icelandic); abi (Japanese); krasnozobaya gagara (Russian); smålom (Swedish).

### Distribution of Species (see map 1)

BREEDS in North America on arctic coasts and islands from Alaska to Greenland, south along the Pacific coast through the Aleutian Islands to the Queen Charlotte Islands and (formerly) Vancouver Island, in the interior of the continent to central Yukon, southern Mackenzie, northern Saskatchewan, northern Manitoba, James Bay, and (formerly) the north shore of Lake Superior, and along the Atlantic coast to southeastern Quebec (including Anticosti Island), Miquelon Island, and northern Newfoundland (Ball Island); and in Eurasia from Iceland and arctic islands and coasts south to the British Isles, southern Scandinavia, northern Russia, Lake Baikal, Sakhalin, the Kurile Islands, Kamchatka, and the Commander Islands. Recorded in summer (and probably breeding) in northeastern Alberta and Newfoundland.

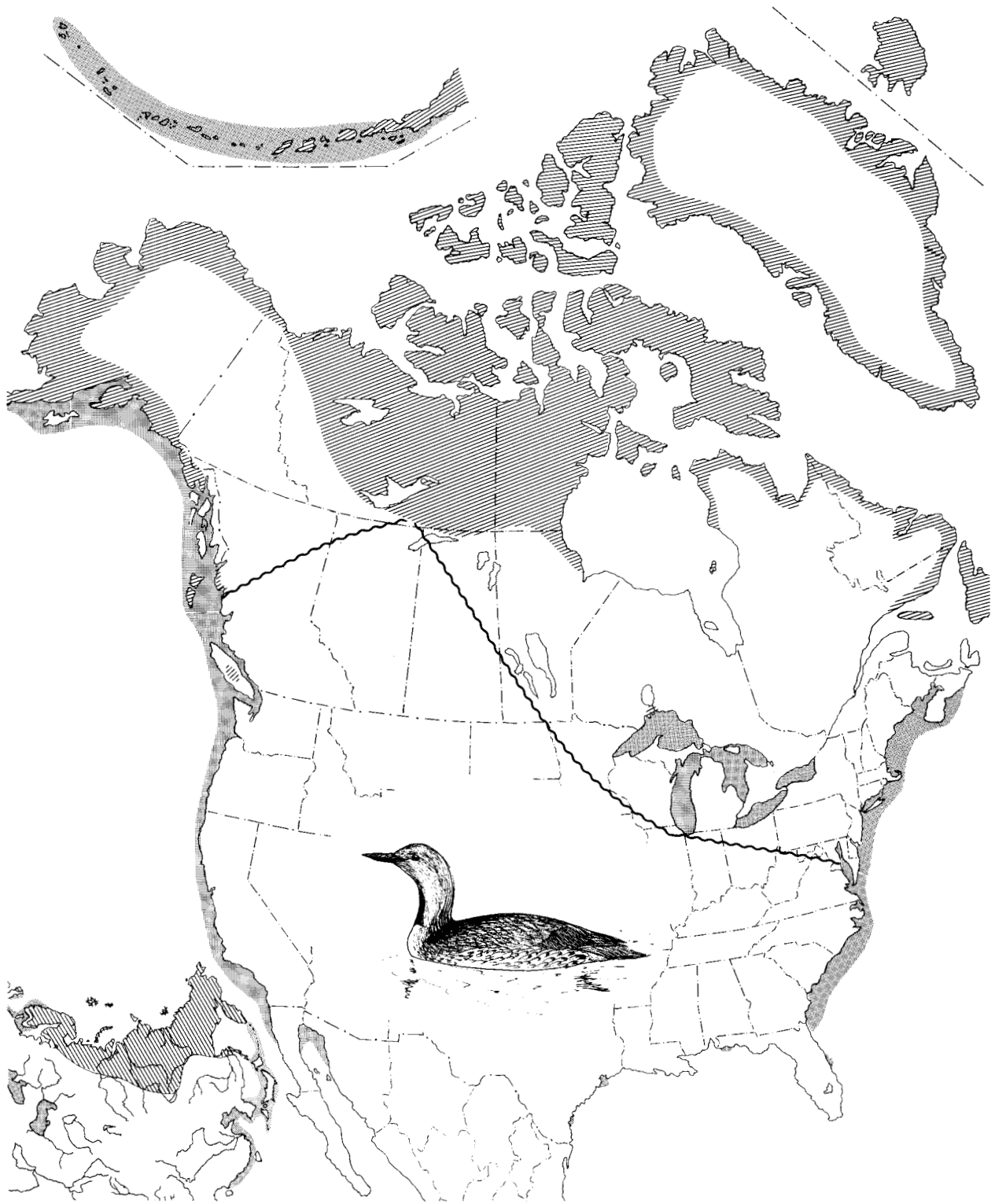
WINTERS in North America primarily from the Aleutian Islands south to northern Baja California and northwestern Sonora, and on the Atlantic coast south to Florida, ranging regularly to the Gulf coast of Florida; and in Eurasia south to the Mediterranean, Black, and Caspian seas, and along the western Pacific coast to China and Taiwan.

### Description (after Witherby et al. 1941)

ADULTS IN BREEDING PLUMAGE (sexes alike). Crown somewhat glossy dark gray, streaked blackish, each feather having an even white margin on each side of

web; upper mantle blackish brown, washed gray and spotted grayish white, each feather having at tip a pair of small grayish white spots as in winter but smaller and less pure white, a few similar feathers on sides of mantle, otherwise rest of upperparts usually unspotted glossy blackish brown; lores, sides of head, chin, sides of throat, and sides of neck dark ash gray; down middle of throat a long patch of dark chestnut (feathers with gray bases), narrow on upper part and increasing to full width of throat at base; immediately below this and on sides of upper breast feathers narrowly streaked blackish brown; rest of breast and belly white; feathers of flanks blackish brown more or less edged white and sometimes with a few small gray spots; under tail coverts as winter; tail feathers blackish brown, very narrowly tipped paler brown; wing feathers as winter; wing coverts much more narrowly and less distinctly fringed grayish white rather than white, and lesser coverts with small grayish spots or fringes and sometimes uniform blackish brown.

WINTER PLUMAGE. Whole crown and back of neck blackish gray, finely streaked white (each feather with blackish center and gray edges with short narrow white streak on each side at tip); rest of upperparts brownish black closely spotted white (each feather having at tip a pair of small white spots well separated and slightly oblong, on scapulars almost rectangular and set obliquely with usually an additional pair of spots proximal to them); underparts white, including lower part of lores, under eye, and side of neck, feathers joining back of neck tipped blackish and giving mottled appearance that occasionally extends onto throat; sides of upper breast and flanks more or less streaked black and white and also spotted; from side to side across vent narrow and somewhat ill-defined dark line; under tail coverts white, lower ones with basal halves dark brown; axillaries white with blackish brown median streaks; under wing coverts white, those covering primaries with pale brown shaft streaks; tail feathers brownish black, narrowly and evenly tipped white; primaries brownish



1. Current North American distribution of the red-throated loon, showing breeding areas (*hatched*), wintering areas

(*shaded*), and southern limits of major migratory corridors (*wavy line*). The Eurasian range is shown on the inset map.

black on outer webs and tips, paler brown inner webs and whitish at extreme base; secondaries blackish brown, inner ones with narrow white fringes at each side of tip; primary coverts as primaries; wing coverts brownish black, feathers narrowly fringed white on each side of tip giving appearance of diagonal short streaks on greater and median but smaller and more spotlike on lesser.

**JUVENILES.** Like winter adult but crown and back of neck more uniform ash gray with narrow inconspicuous blackish brown streaks; rest of upperparts much browner, not so black as adult winter and spots more grayish, not so pure white, and smaller, being narrower and longer and forming narrow triangular edges to feathers, this being especially noticeable on scapulars and wing coverts; underparts white but cheeks, sides of neck, and throat thickly speckled brown; flanks browner than in adults and feathers edged white, not spotted, vent mottled brown; under tail coverts white with very narrow brown margins; lower ones brown with narrow white tips; tail feathers brown narrowly tipped grayish, becoming whitish when worn; primaries and secondaries as adult but all latter narrowly tipped white.

**DOWNY YOUNG.** Variable in color but usually warmer in hue than in the arctic loon, with a drab gray belly rather than white as in other loons (Fjelds  1977).

### Measurements and Weights

**MEASUREMENTS.** Wing (unflattened): males 272.5–292.5 mm (average of 10, 180.2); females 259–81 mm (average of 10, 270.4). Culmen: males 48.2–57.1 mm (average of 10, 52.4); females 46.4–54.6 mm (average of 10, 51). Eggs: average of 20, 73.6 x 45.1 (Palmer 1962).

**WEIGHTS.** In breeding season, males 1,526–2,265 g (average of 17, 1,833); females 1,356–1,887 g (average of 18, 1,543) [various sources]. In winter, 6 males averaged 1,341 g and 9 females 1,144 g (Cramp and Simmons 1977). Estimated egg weight 83 g (Sch nwetter 1967). Newly hatched young weigh about 65 g (Fjelds  1977).

### Identification

**IN THE FIELD.** This is the smallest of the loons, and its short neck feathers give it the slimmest conformation. Its bill is also the weakest and most stiletto-like but has a distinct uptilt that is lacking in the arctic loon. In breeding plumage it is the only loon that lacks distinct white back patterning, has a reddish brown foreneck, and has black-and-white striping extending up the

hindneck and nape. In nonbreeding plumage the red-throated loon may be recognized by its small size, slim conformation, and unusually pale head and neck, with only the crown and hindneck relatively dark. It is thus almost as pale as is the yellow-billed loon's winter plumage, but unlike that species it has a dark-colored bill and lacks a dark auricular patch, and it is much smaller.

**IN THE HAND.** This smallest loon has a wing length that is usually less than 285 mm, and its culmen length is no more than 57 mm. Its measurements overlap considerably with those of the arctic loon, but unlike that species the tarsus is about as long as is the middle toe exclusive of its claw, and the culmen is virtually straight, emphasizing the upward tilt of the lower mandible.

### Ecology and Habitats

**BREEDING AND NONBREEDING HABITATS.** Breeding habitat requirements of this species have been analyzed in Alaska by Bergman and Derksen (1977), who concluded that it prefers to nest in wetland areas occurring in large, shallow, and partially drained lakes of the arctic coastal plain, particularly relatively small, shallow ponds having emergent stands of *Carex aquatilis* and a central open-water zone. Larger ponds or lakes without emergent center vegetation but with stands of *Arctophila fulva* near the shore were also used throughout the summer, though not to the degree typical of the arctic loon. The average wetland area used by red-throated loons covered 0.4 hectare (range 0.1 to 0.8), compared with 3.0 hectares (range 0.7 to 12.1) in the arctic loon. Davis (1972) made an exhaustive comparison of habitat use by these two species and found that pond size is the most critical difference separating their nesting pond habitats. The two species have similar preferences with respect to shoreline features, pond depth, bottom type, water clarity, and general visibility from the pond, and none of these factors limited the suitability of a pond for nesting. Both species preferred island-type nesting areas, and a food supply had to be present within several kilometers, but not necessarily in the nesting pond. The average size of 67 nesting ponds of the red-throated loon in the McConnell River area was 0.32 hectare, while for 46 arctic loons it was 2.22 hectares. Apparently the greater takeoff ability of red-throated loons is a major reason they can exploit smaller ponds than those used by arctic loons. The difference in these two species with respect to space requirements is further pointed out in table 30.

Nonbreeding habitats have not been nearly so well

documented, but in general this species frequents shallow nearshore coastal waters, occasionally even freshwater lakes, reservoirs, and larger rivers, including the Great Lakes. Shallow tidal areas in estuaries, with associated submerged mud flats, seem to be favored foraging areas. On migration the birds often move along rivers from lake to lake or lagoon to lagoon or follow the shoreline of coasts between ice floes and coastal lagoons, concentrating in estuarine inlets and avoiding the open sea (Portenko 1981). Densities in the Gulf of Alaska and eastern Bering Sea are apparently low, and the birds seem to be limited to bay habitats (table 5).

**SOCIALITY AND DENSITIES.** This is perhaps the most gregarious of the loons during nonbreeding periods, and loose flocks sometimes develop that have been reported to number as large as 1,200 birds during fall migration on the Great Lakes (Palmer 1962). McIntyre (1975) noted that on wintering areas of coastal Virginia red-throated loons tended to feed in small groups among channels where the water currents were swift, whereas common loons foraged singly and used quieter waters in the area. However, there does not appear to be any evidence that the birds forage cooperatively, by driving fish into shallower waters where they can more easily be captured, for example. It is likely that pairing occurs before or during spring migration, since pairs typically arrive on breeding areas simultaneously.

Densities of breeding birds have been estimated by various authors, including Bergman and Derksen (1977), who found that over five years the average breeding density ranged from 125 to 167 hectares per pair on sample 2.6 square kilometer plots. The average densities of loons observed in summer over an area of 42,000 square kilometers of coastal tundra ranged from 0.6 to 1.7 birds per square kilometer, while the entire area of 92,000 square kilometers surveyed in the National Petroleum Reserve supported 0.35–0.40 bird per square mile. Red-throated loons composed 5 percent of this total, suggesting a density of only about one pair per 60 square kilometers (King 1979). Locally in the Shetland Islands the densities of red-throated loons may be quite high, approaching one pair of birds per square kilometer of water and associated land, or up to as many as 11 pairs sharing only 18 hectares of actual water area (Merrie 1978). In this area much feeding of the young was apparently done in shallow coastal waters within a few kilometers of the nesting pond, and thus these extremely high nesting densities are somewhat misleading. If these nearby coastal waters are included in the estimates a mean breeding density of 2.5 square kilometers per pair was estimated for nine different Shetland Islands and Scotland study areas (Merrie 1978).

**COMPETITORS AND PREDATORS.** Of the other species of loons, only the arctic loon is likely to be a significant competitor with the red-throated loon. Davis (1972) analyzed the habitat requirements of both species and noted that in one area where only red-throated loons nested that species exhibited only a slight tendency to use bigger ponds in the absence of the larger arctic loon. In high-density offshore areas the birds exhibited a random selection of various-sized ponds, and only on the mainland did they tend to choose larger ponds. Davis attributed this to an antipredator response rather than to a lack of competition with arctic loons.

Predators are apparently a major cause of egg losses in this species. Davis (1972) reported predation as the primary cause of egg mortality in his study and listed the chief egg predators as the parasitic jaeger (*Stercorarius parasiticus*), herring gull (*Larus argentatus*), sandhill crane (*Grus canadensis*), and arctic fox (*Alopex lagopus*). Of these, the jaeger was responsible for more egg losses than the rest of the predators combined. Predators of young and eggs were listed as humans, gulls, and red foxes (*Vulpes fulva*). Bergman and Derksen (1977) found that nests of red-throated and arctic loons were probably destroyed by arctic foxes, jaegers, and glaucous gulls (*Larus hyperboreus*), although for most nests the exact cause of failure was not determined. Bundy (1976, 1978) reported a "considerable" loss of both chicks and eggs in his study area on the Shetland Islands and judged that hooded crows (*Corvus corone*), jaegers, great skuas (*Stercorarius skua*), or gulls including great black-backed gulls (*Larus marinus*) were most probably responsible, although he obtained little direct evidence of this. The great black-backed gull has also been implicated as a serious predator on chicks in eastern Canada (Johnson and Johnson 1935). Predation on young chicks by the bald eagle (*Haliaeetus leucocephalus*) has also been observed (Reimchen and Douglas 1984).

Like other loons, this species probably has few serious predators once fledging has occurred, but substantial losses result from entanglement in fishing nets. Parmelee, Stephens, and Smith (1967) noted that a relatively large number were found caught in such nets in spite of the birds' relative scarcity in southeastern Victoria Island.

### General Biology

**FOOD AND FORAGING BEHAVIOR.** The best information on food intake by wintering birds comes from Madsen's (1957) study of 203 birds taken between October and February. These birds had eaten fish for the most part, if not exclusively, with common cod (*Gadus collarias*)



composing over half the total food by volume and present in over 70 percent of the birds examined. These fish measured up to 25 centimeters long. Gobies (*Gobius* spp.) were second in frequency of occurrence, and sticklebacks (*Gasterosteus* spp.) were third. Herring (*Clupea harengus*) were fourth in frequency, and over 80 percent of the sample had fed exclusively on one or more of these four types of fish. More than half had eaten a single type of fish, and about a third contained only two types of fish. The only nonfish remains were traces of crustaceans, polychaetes, and bivalve mollusks, at least some of which no doubt originated from the stomachs of prey. The total size range of fish was from very small (under 3 centimeters) to at least 25 centimeters.

On the breeding grounds, foods taken are less well known, but Davis (1972) reported that adults fed their young a variety of fish including capelin (*Mallotus villosus*), slender eelblenny (*Lumpenus fabricii*), sand lance (*Ammodytes dubius*), arctic char (*Salvelinus alpinus*), grayling (*Thymallus thymallus*), and unidentified sculpins. Few of these fish were obtained on the nesting ponds, since most are marine species. Bergman and Derksen (1977) similarly found that the adults fed their young on fish obtained from adjacent coastal waters. Capture of two chicks confirmed that they had been fed arctic cod (*Boreogadus saida*), and observations of wild birds feeding their young suggested that this species is the major food of young birds in that area. Crustaceans and aquatic insects may also be fed to the young during the first few days after hatching (Palmer 1962). The length of 11 fish carried to nearly fledged young birds in one study averaged 15.6 centimeters (range 9–20) and the estimated average weight was 50 grams (Norberg and Norberg 1976). In a more complete study, Reimchen and Douglas (1984) found that young were fed an average of eleven times a day, with a gradually increasing total amount of fish being fed through the fledging period as progressively large prey fish were brought to them. Major prey fish included shiner perch (*Cymatogaster aggregata*), unspecified osmerids, clupeids, and gadids, sand lance, gunnels (*Pholis*), and pricklebacks (*Lumpenus sagitta*), with average lengths ranging from 7.9 to 13.7 centimeters and average weights ranging from 1.5 to 22.5 grams. The young apparently are fed throughout the entire 7 week fledging period.

Most foraging seems to be done in relatively shallow waters less than 10 meters deep, with dives lasting no more than 90 seconds. These observed limits seem to be shallower and shorter than those reported for other loons (tables 10–12), although the data are still extremely limited in this regard. Reimchen and Douglas (1980) noted that average diving times of red-throated

and common loons foraging in the same lake were very similar, although in red-throated loons 70 percent of all diving was in water less than 1 meter deep, whereas in the common loon only 15 percent of the dives were in such shallow water. In conjunction with this, the birds tend to winter on shallower waters than are typical of the other loons, though they may move to deeper waters during the night. Foraging flights of up to several kilometers from nesting ponds to sources of prey fish are regular in this species and are apparently unique among loons. Reimchen and Douglas (1984) concluded that breeding adults exhibit foraging adaptations that minimize the number of daily foraging flights, such as returning with prey nearly the optimal size for their variably grown chicks, but their preferential use of marine fish as prey, even when freshwater prey species are readily available, is of questionable adaptive value.

**MOVEMENTS AND MIGRATIONS.** A substantial coastal migration occurs on both the Atlantic and Pacific coasts of North America, with a very limited interior movement along the Mississippi River valley. As much as 12 weeks may elapse from the time of departure from southern wintering areas until arrival on tundra breeding grounds. Subadult nonbreeders also move north to coastal waters of the arctic or subarctic and remain there through the summer. Fall movements are also rather leisurely, with most migrants traveling coastally except for those passing through the Great Lakes, where large numbers of loosely associated birds sometimes assemble in October (Palmer 1962).

The red-throated loon is more maneuverable in flight than is the arctic loon as a result of its lower body weight relative to wing length and other mensural features (Davis 1972). Data on comparative flight speeds in these two species are not available, but it is known that the red-throated loon not only can take flight from very small water areas but can also, if pressed, take off from land. Normally, however, the birds skitter along the water surface for 15–40 meters and take off at about 35 kilometers per hour. The average flight speed during fishing flights is 60–64 kilometers per hour (Norberg and Norberg 1971).

### Social Behavior

**MATING SYSTEM AND TERRITORIALITY.** Like the other loons this species is strongly monogamous, and pairs probably renew their pair bonds regularly each year as long as both are available. The high level of territorial stability Davis (1972) noted over a three-year period indicates such prolonged pair associations. Of 39 territories, 23 had nests all three years, 7 had nests during two

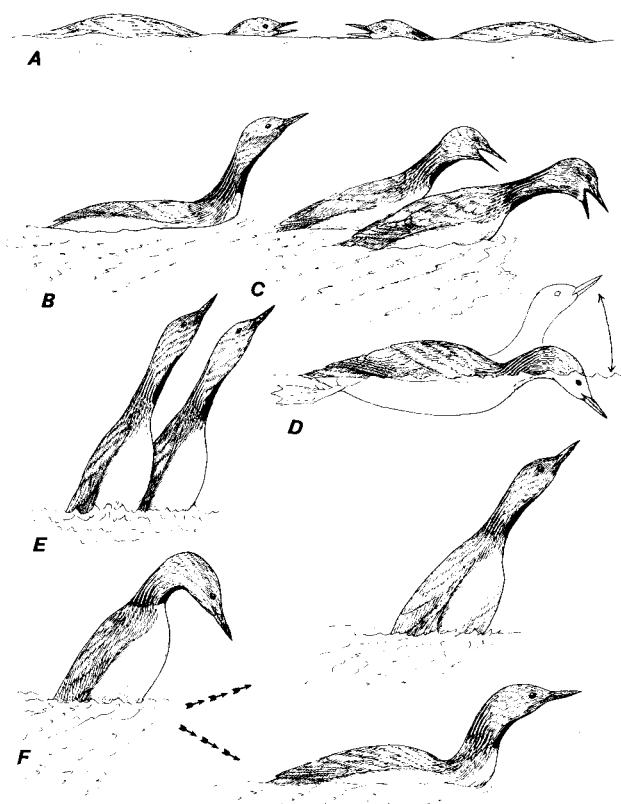
years, and 2 had nests only one year. Seven had nests in two years and a resident pair was present the third year, and 2 had nests one year and a pair was present the next. Thus 30 territories were used all three years, a high number considering that in one of the three years only 32 total territories were occupied, as a result of severe spring flooding of breeding ponds. Davis concluded that the birds tended to modify territory size according to the number of ponds present, with from 1 to 4 ponds present in 36 territories, averaging 2.86 ponds. The actual ponds used for nesting often changed from year to year, especially if the previous year's effort had been unsuccessful. Although the data were not statistically significant, trends indicated that birds with a larger number of ponds on their territories had a higher chance of nesting success than did those with single-pond territories.

Davis believed that loons might select their breeding territories during the late summer before the breeding season in which they were to be used, partly because he observed that both arctic and red-throated loons spent a good deal of time on territory and in territorial defense even after their eggs or young had been lost. In red-throated loons the number of territorial encounters was about the same on territories with failed nests as during the prelaying period, but these encounters lasted longer and often included sustained aerial components. Thus red-throated loons were likely to call toward flying conspecifics intruding on their territories, causing them to change course and fly away. Since males sometimes were able to obtain new mates within a few days after the loss of their old ones, it is likely that pair bonding may also occur on the breeding grounds rather than wintering areas.

**VOICE AND DISPLAY.** Except for the long call, the vocalizations of this species are the same in both sexes. The long call is a harsh, loud, cooing call that is strongly pulsed, with the pulses varying in pitch and repeated up to ten times. The female's call is longer and softer; the call is often uttered as a duet during territorial encounters, contacts between mates, and "frog jumping" displays. A second major call is "wailing" or "mewing," a catlike meowing that lasts about a second and is of descending pitch. This call is apparently aggressive in function, and together with the long call is often uttered toward intruders flying over the territory. The croaking call is likewise aggressive and consists of short, barking crowlike notes repeated about four times per second. A moaning call is uttered as a contact call between mates and between parents and young; it is soft and low-pitched. Chicks utter chirping calls while begging and to attract parents, and a version of the long

call given in response to the same call by adults (Bylin 1971; Cramp and Simmons 1977).

Besides the classic descriptions of Huxley (1923), the displays of this species have been described by Bylin (1971) and Sjolander (in press; and cited in Cramp and Simmons 1977). Sjolander's observations seem especially useful, considering his wide comparative experience with other loon species. Initial pair bonding is probably achieved by young males' establishing territories and waiting for females to join them. Because of the small territories and frequent foraging outside their boundaries, territorial behavior is more complex than in the other loons, and because returning mates are often greeted by essentially agonistic mutual "triumph ceremony" displays (fig. 30A), such behavior has often been mistaken (as, for example, by Huxley) for courtship. When an intruder swims into or flies over a territory it is greeted by wailing calls and long calls by the resident birds. They will swim up to an intruder in a neck stretched and bill tilted (fig. 30B) "alert posture" ("start-



30. Social behavior of the red-throated loon (after Cramp and Simmons 1977 and Bylin 1971): A, mutual calling or "triumph ceremony"; B, alert posture; C, snake ceremony; D, bill dipping; E, plesiosaur race; F, penguin posture, followed by plesiosaur posture (*above*) or normal swimming (*below*).

ing position" of Bylin) and then often begin splash diving or bill dipping (fig. 30D). The resident pair may then perform the "snake ceremony," in which they swim in parallel with their necks outstretched diagonally while uttering long calls in duet (fig. 30C). Or they may form a silent but more intense "plesiosaur race" (fig. 30E), with their bodies partially raised from the water and their bills tilted upward as they swim in parallel. The intruding bird may participate in such races. A "penguin posture" (fig. 30F) similar to that assumed during the plesiosaur race may also be adopted by single birds and is probably the equivalent of the fencing posture of other loons. This posture may grade into a typical plesiosaur race posture or may terminate in a normal swimming posture. Rushing chases over the water are sometimes also performed, as in the other loons.

Precopulatory behavior in this species reportedly consists of mutual bill dipping and splash diving. Holding their necks diagonally outstretched, the birds begin to bill dip with increasing speed and sometimes dive past each other (Bylin 1971). Actual copulation is preceded by search swimming by the female, who moves along the shoreline in a crouched posture, eventually going ashore and inviting the male by remaining in this characteristic position with retracted neck and withdrawn bill. The male approaches, mounts, and copulates without specific displays except for sometimes uttering moaning calls. The female may remain on the shore for a few minutes afterward, sometimes making nest-building movements, but specific mating platforms are not needed for successful copulation (Cramp and Simmons 1977).

## Reproductive Biology

**BREEDING SEASON AND NESTING SUBSTRATE.** In arctic Alaska the egg-laying period extends from June 8 to early July, and in the Canadian arctic it lasts from mid-June onward (Palmer 1962). In southern Canada egg records have been obtained as early as May 25 (Johnson and Johnson 1935), and on Victoria Island the egg-laying period is apparently from about June 27 to early July (Parmelee, Stephens, and Schmidt 1967). At even higher latitudes on northeastern Devon Island the observed egg-laying period was July 2–13, or about 2 weeks after the birds' initial arrival (Hussell and Holroyd 1974).

Nesting pond characteristics have been thoroughly studied by Davis (1972). He found that these birds choose small ponds (averaging about 0.25–0.40 hectare), regardless of whether arctic loons are nesting in the same area. The largest pond used in his study areas was 1.125 hectares, and the smallest was 0.01 hectare. Ponds with shorelines that were steep, rocky, or covered with

thick and shrubby vegetation were not used. Ponds with islands or "marsh islands" (islands surrounded by marshy vegetation) were preferred over those with wet grassy substrates lacking these features, and dry shoreline was the least preferred nest substrate. Apparently ponds having a minimum amount of suitable shoreline for nest sites are as suitable as those having extensive areas of such shoreline. Although there is strong territorial fidelity from year to year, there is little fidelity to specific ponds for nesting, much less to nest sites. Pond depth is apparently more important than might be imagined, since loon chicks typically dive when frightened and escape by swimming along the bottom and stirring up mud, obscuring them from view. The minimum suitable depth for red-throated loons is probably 26–33 centimeters, and average depths are 39 centimeters. The bottom of the pond should preferably have a layer of loose sediment that can easily be stirred up by an escaping chick. Unlike arctic loons, red-throated loons do not require a food supply in the nesting pond. A final factor that might influence the choice of nesting substrate is general visibility from the nest site, particularly insofar as ease of rapid takeoff might be affected.

**NEST BUILDING AND EGG LAYING.** According to Davis (1972), this species constructs two types of nests. One is a rudimentary structure on dry shore, simply a hollowed area surrounded by small amounts of vegetation pulled out of nearby water. This nest type can be completed and ready for the first egg within a few hours. The second type of nest is constructed above a submerged site. It is built up of bottom mud and aquatic vegetation, and it apparently requires many hours of work before the first egg can be laid, possibly as long as several days. This type of nest may be somewhat safer from land-based predators and is apparently favored by loons if their ponds offer both dry and wet locations. Of 90 observed nesting attempts, 79 different sites were used, with only 9 cases of reuse of an earlier nest site. The eggs are laid at intervals of 2 days, but hatching typically occurs after a one-day interval, so incubation must begin almost immediately. One-egg clutches are not infrequent in this species; Bundy (1976) reported an average clutch size of 1.76 eggs for 39 clutches, 21 percent of the clutches being of single eggs. Davis (1972) found 12 one-egg clutches and 61 two-egg clutches. He noted that two-egg clutches were less likely to be completely lost than one-egg clutches, and that one-egg clutches had a lower hatching success than did the remaining eggs of two-egg clutches.

**INCUBATION AND BROODING.** Both sexes incubate, with the female probably doing the larger share. The in-

cubation period is relatively short, 25–26 days being reported by Hunsell and Holroyd (1974) for arctic Canada and 27.05 days by Cramp and Simmons (1977) for a sample of 19 eggs on the Shetland Islands. Johnson and Johnson (1935) reported that an abandoned egg was hatched under a chicken 38–40 days after the start of incubation, but this is certainly a case of unnaturally extended incubation.

**GROWTH AND SURVIVAL OF YOUNG.** Of a total of 134 eggs, Davis (1972) found that 91 hatched (68 percent) and that an average of 1.43 young hatched from two-egg clutches while 0.33 young per nest hatched from single-egg clutches. Overall brood survival for a three-year period was 39 chicks out of a total of 101, a 38.6 percent fledging success. Apparently the fledging success was not influenced by brood size at hatching; thus the presence of a second chick had no effect on the survival of the older one. However, the first-hatched young survived better than its younger sibling unless sufficient food was available. The second-hatched chick was fed only after the first had ceased to beg for food, which tends to result in maximum efficiency of brood-size regulation. The fledging period (hatching to initial flight) was determined to be 55–58 days (3 birds) by Peterson (1976), and Bundy (1976) estimated that juvenal plumage was attained in an average of 42 days for 27 chicks. In the early stages of chick growth one parent remains with the young while the other forages for food, and brooding is nearly continuous during the first week after hatching. After the young are 2 weeks old both adults begin to leave the territory simultaneously to forage for food for themselves and their young.

**BREEDING SUCCESS AND RECRUITMENT RATES.** Bundy (1976) estimated an overall breeding success rate of 0.41 young fledged per pair for 63 pairs in Scotland. Cyrus (1975) reported that 15 nesting pairs raised 5 young to fledging (0.33 young per pair), with most losses occurring in the egg stage. Davis (1972) reported an overall hatching success of 67.9 percent for 134 eggs and a survival rate of 38.6 percent for 101 hatched chicks, an approximate breeding success of 26.2 percent. With an average clutch size of 1.83 eggs (87 nests), the number of young raised per pair would be 0.47 chick. Because of the unknown percentage of nonbreeders in the population, recruitment rates cannot be derived from these figures.

### Evolutionary History and Relationships

There seems little doubt that the nearest relative of the red-throated loon is the arctic loon, and Davis (1972) has postulated that these forms were isolated in

Pleistocene times into one occupying a colder arctic refugium and the other occurring south of the continental ice shelf. The former population, ancestral to the red-throated loon, became adapted to breeding on fast-thawing small ponds, which eventually placed the form at a competitive disadvantage with the larger arctic loon where the two met on larger and deeper waters.

### Population Status and Conservation

There are no estimates available of North American or world populations of this species. King and Sanger (1979) assigned an oil vulnerability index of 49 to the red-throated loon, or somewhat less than the average (55) they calculated for the entire loon family.

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## Arctic Loon (Black-throated Diver)

*Gavia arctica* (Linnaeus)

**OTHER VERNACULAR NAMES:** Black-throated loon; Pacific loon; sortstrubet lom (Danish); Prachttaucher (German); glitbrusi (Icelandic); ohamu (Japanese); cheronozobaya gagara (Russian); storlom (Swedish).

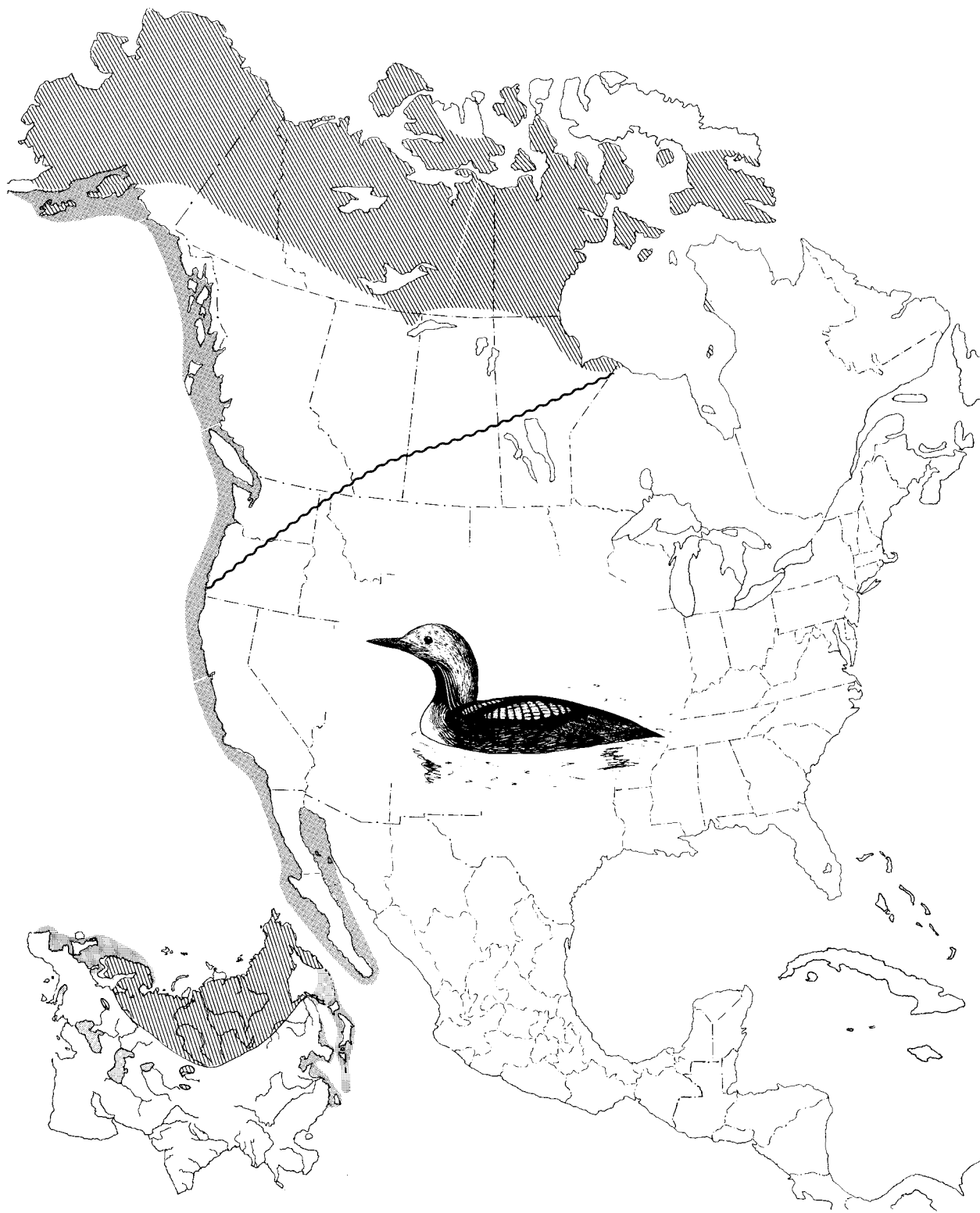
### Distribution of North American Subspecies (See Map 2)

*Gavia arctica pacifica* (Lawrence)\*

**BREEDS** in North America from Cape Prince of Wales and Point Barrow, Alaska, east to Melville Peninsula and southern Baffin Island; south to the Alaska Peninsula, Kodiak Island, northern Saskatchewan, northern Manitoba, and northern Ontario; east to Labrador Peninsula (casually). Recorded in summer at the Carey Islands, near 77° N at the northern end of Baffin Bay, Devon Island, Hudson Bay, and James Bay, and on the Pacific coast from the Sitkan district of Alaska to the Queen Charlotte Islands, northwestern Washington, and Oregon; also breeds in Scotland, Norway, Finland, and northern Russia south to northern Germany, Baltic states, and to 55° N in Russia.

**WINTERS** mainly along the Pacific coast from the Aleutian Islands south to Guadalupe Island, southern Baja

\*This form is sometimes considered a distinct species (Flint and Kishchinski 1982), since apparent breeding sympatry of *G. a. pacifica* with *G. a. viridigularis* has been reported. This taxonomic change was also adopted by the AOU (*Auk* 102, 680) after manuscript submission. The name Pacific loon thus applies to this form, while *viridigularis* is sometimes called the green-throated loon.



2. Current North American distribution of the arctic loon; symbols as in map 1.

California, the western side of the Gulf of California, and along the eastern side to southern Sonora; also on the coasts of Japan.

*Gavia arctica viridigularis* Dwight

BREEDS in northeastern Siberia, from the Khatanga River to Kamchatka and Sakhalin Island, and locally at Cape Prince of Wales, Alaska, where it is seemingly sympatric with *pacifica* (Bailey 1948).

WINTERS south to the Baltic Sea, Sakhalin Island, and Japan.

### Description (Modified from Witherby et al. 1941)

ADULTS IN BREEDING PLUMAGE (sexes alike). Forehead and lores dark slate gray; crown and back of neck extending onto sides as nape ashy gray, base of back of neck merging into bluish black of mantle and upperparts; down each side of mantle a series of short rows of white spots, similar to but longer and broader than columns of larger spots on scapulars, rest of upperparts uniform bluish black but sides of back and rump tinged brown; sides of head as crown but below eye and lower ear coverts washed blackish brown merging into black of chin; throat black slightly glossed greenish purple; across upper throat a prominent line of short white parallel vertical streaks, down sides of neck long white streaks; flanks glossy black, and a blackish brown line across vent; rest of underparts white, but lower under tail coverts blackish brown, tipped with white; tail feathers brownish black with no white tips; wing coverts glossy black with twin oval white spots, but feathers along front edge of wing and primary coverts unspotted.

WINTER PLUMAGE. Forehead, crown, and back of neck brown washed grayish; base of back of neck and rest of upperparts blackish brown and somewhat glossy, some scapulars with a pair of small subterminal whitish spots; underparts white; white on sides of head extending from base of lower mandible under eye and slightly backward on sides of nape with slight mottling at juncture of white and brown; usually a narrow line of brown-tipped feathers across upper throat; flanks dark brown, a (usually incomplete) narrow dark brown line across vent; lower under tail coverts blackish brown tipped with white, upper ones white; axillaries white, sometimes with dark brown shafts and terminal shaft streaks; under wing coverts white, sometimes with pale brown median streaks; tail feathers black, tipped with white; wing feathers with glossy brownish black outer webs and tips, dark brown shafts and paler brown inner webs; upper wing coverts brown.

JUVENILES. Crown and back of neck like adult winter but browner and less grayish; rest of upperparts dark brown, feathers with ashy gray margins, prominent on mantle and scapulars, less conspicuous on rump and upper tail coverts; sides of neck adjoining white of throat more finely mottled brown than in adult and mottling sometimes extended onto throat; brown line across vent prominent; lower under tail coverts dark brown with narrow white tips; tail feathers dark brown with narrower white tips than in adult; wing feathers and primary coverts as adult but all wing coverts with grayish brown tips.

DOWNY YOUNG. First down rather short, thickly covering whole body and especially thick on underparts. Upperparts dark mouse brown, underparts paler, middle of breast and belly grayish, immediately around eye whitish. Second down like first but decidedly paler both above and below, center of breast and belly whitish. Iris reddish brown, legs and feet dark greenish gray, bill dark gray (Fjeldså 1977).

### Measurements and Weights

MEASUREMENTS (of *pacifica*). Wing (flattened): males 285–307 mm (average of 10, 299.6); females 281–307 (average of 10, 295.7). Culmen: males 49.5–55.0 mm (average of 10, 51.9); females 49–54 mm (average of 10, 50.8). Eggs: average of 20, 76.0 x 46.7 mm (Palmer 1962). Measurements of *viridigularis* average about 5–10 percent larger.

WEIGHTS (of *pacifica*). In breeding season, males 1,382–2,409 g (average of 6, 2,025); females 1,616–2,152 g (average of 9, 1,823) (various sources). Estimated egg weight, 95 g (Schönwetter 1967). Weights for *viridigularis* average larger than for *pacifica*; Dementiev and Gladkov (1968) report males of that race weighing 3,280 and 3,792.5 g and females from 2,255 to 3,075 g (average of 3, 2,665 g). Newly hatched young, presumably of *arctica*, weigh about 75 g (Fjeldså 1977).

### Identification

IN THE FIELD. This is a medium-sized loon, with a bill that is rather tapering and less uptilted than that of the red-throated loon. In breeding plumage the silvery gray nape and lower neck, with long lateral neck striping and a blackish foreneck patch, are distinctive. The back is extensively spotted with white patterning, including two large areas of white on the wings and two smaller areas on the upper back. In nonbreeding plumages the white areas on the mantle are lacking and the upperparts are uniformly dark, with white limited to the

breast, foreneck, and lower half of the head. The bird is thus appreciably darker than the red-throated loon in corresponding plumage and is approximately the same darkness as the common loon. However, besides being smaller, it also lacks the pale "eyebrows" typically present in that species. Reportedly the best field marks for separating the arctic loon from the common loon in nonbreeding plumages include the arctic loon's tendency to exhibit a dark "chin strap," its more sharply demarcated patterning on the sides of the neck, and its more distinctly transversely barred back. Its nape is typically paler than that of the common loon, and a white flank spot is sometimes also visible at the waterline near the tail. The smaller bill size of the arctic loon is a less useful distinction from the common loon than might be imagined (*Loon* 52:59–61).

**IN THE HAND.** This is a medium-sized loon, with a wing length no greater than 315 mm, a culmen length no more than 70 mm, and the tarsus longer than the middle toe (including its claw). It is very similar in culmen length to the red-throated loon, but unlike that species the culmen is slightly convex rather than straight, producing a more tapering bill shape. Separation of the forms *pacifica* and *viridigularis* is rather difficult, but *viridigularis* has a bill that is longer (over 55 mm from forehead feathering, vs. under 55 mm for *pacifica*), and heavier (over 15 mm high from forehead feathers, vs. under 15 mm for *pacifica*) and is generally larger in other measurements. *Pacifica* also exhibits brown-tipped axillaries, a thicker-appearing neck, and a somewhat paler head and hindneck coloration (Flint and Kishchinski 1982). The gloss of the throat area also tends toward greenish in *viridigularis* and purple in *pacifica*. Green-throated birds in the size range of *pacifica* have been found in the area of Barrow, Alaska (Bailey 1948), but generally nonoverlapping measurements appear to be typical of both bill length and bill height as well as tarsal length (over 75 mm for *viridigularis*, under for *pacifica*) for these two forms.

## Ecology and Habitats

**BREEDING AND NONBREEDING HABITATS.** Breeding habitats have been analyzed by Davis (1972), who identified several characteristics typical of nesting ponds. On his major study site at McConnell River there were 250 pond areas ranging in size from 0.07 to 21.37 hectares, and the average pond size used during each of three years ranged from 2.13 to 2.73 hectares, with a maximum of five nests found one year on the largest pond. The smallest pond used was 0.225 hectare, but generally the birds used the largest pond available to

them. The birds selected ponds that offered islands or wet grassy areas for nests, especially islands. Although there was a high level of territorial fidelity from year to year, nest sites varied greatly. Pond depth of those ponds used by loons ranged from 30 to 90 centimeters, averaging 52 centimeters, and these ponds were rich in bottom sediments that could be stirred up to facilitate escape by chicks. Adults fed their chicks on foods obtained on the nesting territories, which consisted of fish and various invertebrates. Finally, areas that offered excellent visibility and protected the nest from wave action were apparently favored. In Sweden the area of the lake (minimum 56.5 hectares, average 212 hectares) is apparently important, as is transparency of the water for fishing opportunities (Lindberg 1968). Studies by Dunker (1974) in Scandinavia suggest that breeding territories there are associated with lakes at least 50 hectares in area, in conjunction with an estimated minimum territorial requirement there of at least 20 hectares and the need for an extensive feeding area because of generally low densities of available food. Marginal vegetation for hiding nests was also regarded as important. Dunker suggested that breeding habitats of all loons are generally associated with shallow lakes of glacial origin throughout the Holarctic region.

Nonbreeding habitats consist primarily of coastal areas that are usually fairly close to land, but there is little use of inland lakes, reservoirs, or large rivers. In the Gulf of Alaska and eastern Bering Sea, bay and shelf habitats are used almost exclusively, with very few birds occurring on shelfbreak and oceanic areas (table 5).

**SOCIALITY AND DENSITIES.** Davis (1972) noted that about 35 pairs of birds nested on his study area of 16.5 square kilometers at McConnell River, giving an overall breeding density of one pair per 47 hectares. Bergman and Derksen (1977) found an average five-year breeding density of one pair per 125 hectares and a three-year nest density of a nest per 160 hectares on their study plots at Storkersen Point in northern Alaska. Derksen, Rothe, and Eldridge (1981) found similar densities of up to one pair per square kilometer, with preferential use of deep *Arctophila*-dominated wetlands, especially for brood rearing. King (1979) reported that arctic loons composed an estimated 72 percent of the total summer population of loons on the National Petroleum Reserve. The average loon density of 0.6–1.7 loons per square kilometer over 42,000 square kilometers of the coastal plains habitat suggests that in such regions the arctic loon may have an overall breeding density of about one pair per 200 hectares. Some additional estimates of breeding densities are shown in table 30.

Like all loons, arctic loons are highly territorial and

intolerant of conspecifics during the breeding season. Bergman and Derksen (1977) found an average internest distance of 640 meters for 41 nests and a minimum observed distance of 250 meters. Davis (1972) found that arctic loon territories coincided with shoreline boundaries and scarcely varied at all from year to year. Thirty of 35 territories were used in all of three years, and 3 of the remainder had nests in two of the three years. The 2 remaining territories had nests one year and birds present during a second year. Actual territorial size was estimated as 3.66 hectares, ranging from 1.125 to 9.54 hectares. Davis believed that this represented a nearly saturated density, though territorial defense was not very time consuming and was apparently not a major drain on the time budget for these birds. Furthermore, arctic loons only very rarely entered the territories of red-throated loons, though they dominated them socially when equally matched numerically. Evidently the two species maintain mutually exclusive territorial behavior, which is probably facilitated in large measure by their marked tendency to select different-sized ponds.

**COMPETITORS AND PREDATORS.** As just noted, red-throated loons are strong competitors with arctic loons, but differences in territorial requirements tend to reduce the incidence of interspecific competition on breeding areas. When interspecific territorial intrusion occurs arctic loons eliminate red-throated loons faster than they do conspecifics, but at about the same rate as red-throated loons evict arctic loons when the latter trespass on their territories. Generally, red-throated loons are less likely to intrude on arctic loon territories than the reverse, and arctic loons repel such intruders faster than they evict intruders of their own species, indicating a highly directed type of aggression (Davis 1972).

Predators of arctic loons eat mainly eggs and small young. Bergman and Derksen (1977) judged that the arctic fox (*Alopex lagopus*) might have been a major nest predator in their study area and believed that jaegers (*Stercorarius* spp.) and glaucous gulls (*Larus hyperboreus*) were also responsible for some nest losses. Similarly, Peterson (1976, 1979) found that the red fox (*Vulpes vulpes*), jaegers, and glaucous gulls were the major cause of egg losses in her Alaskan study areas. She judged that foxes caused most destruction of shoreline nests and that jaegers and gulls were major predators on island sites. In one year an estimated 95 percent of the nests were destroyed, apparently because of the relative absence of alternative prey species. Furthermore, loon eggs tended to be taken late in the incubation period, especially after the goose hatching period, until which there was an abundant supply of relatively conspicuous

eggs for the nest predators. In Scandinavia the hooded crow (*Corvus corone*) is an important nest predator of this species (Lehtonen 1970). As with other loons, there is probably little danger from predation after fledging, but the birds are susceptible to heavy losses from fishing nets (Parmelee, Stephens, and Schmidt 1967).

## General Biology

**FOOD AND FORAGING BEHAVIOR.** The best summary of foods taken during the fall and winter season is that of Madsen (1957), who examined 145 birds obtained between October and February and found food remains in 123. All of these contained fish remains, and over half had been feeding on gobies (Gobiidae, especially *Gobius* spp.). The second most important food was cod (*Gadus callarias*), including fish to 25 centimeters long, and the third-ranked food source was sticklebacks (*Gasterosteus* spp.). Collectively these three food sources accounted for about 90 percent of the total diet, and 80 percent of the samples contained nothing but these three types of food. About half the birds had eaten only a single kind of fish, another third two kinds, and about a tenth three kinds. Several other types of fish were present as minor food types, and there were also small quantities of invertebrates (crustaceans, polychaetes, mollusks, insects), at least some of which probably were in the stomachs of fish prey. Such crustaceans as crayfish, crabs, and prawns may be taken locally from the sea or in fresh water, judging from other studies. Based on all available sources, a summary of major foods of this species is provided in table 13. Generally small shoal fish seem to be the preferred foods at nearly all times of year, based on available information. Cramp and Simmons (1977) have summarized the European data effectively.

Foods taken on the breeding grounds are less well known, but Davis (1972) reported that the adults fed their chicks on sticklebacks (*Pungitius pungitius*), grayling (*Thymallus thymallus*), fairy shrimp (Anostraca), tadpole shrimp (Notostraca) and other unidentified invertebrates. Likewise, Lehtonen (1970) found that for the first 10 days after hatching the chicks are fed on aquatic invertebrates but later shift to fish eating.

Prey are captured by sustained dives, in waters of varied depths, but with most dives averaging about 45 seconds and occurring in water 3–6 meters deep (Cramp and Simmons 1977). A maximum dive duration of 5.04 minutes and a maximum lateral movement of more than 500 meters have been observed (Lehtonen 1970). However, most fishing dives last less than a minute, and only rarely are they over 2 minutes in duration. Appar-



ently the maximum reported depth of dive for this species is 46 meters according to Lehtonen.

**MOVEMENTS AND MIGRATIONS.** Takeoff is achieved only with difficulty in this species and requires a running start of from 40–60 meters (against a headwind) to 120–200 meters (in windless conditions). In still weather a flight speed of about 65–80 kilometers per hour can be attained. Flight is seen especially often in later summer, between August 15 and October 1, primarily during midmorning hours (6–10 A.M.) and again in the evening (6–10 P.M.) (Lehtonen 1970).

As with the other loons, little is known of migration routes and relative numbers of migrating birds. Unlike the red-throated loon, virtually all the wintering of this species occurs along the Pacific coast, fairly commonly extending north to Vancouver Island. There it is mainly a migrant, with the spring migration primarily from late April onward, peaking in May or early June. The fall migration begins in September and is largely offshore. Average flock size from October through March was 4.3 birds (range 1–25) (Hatler, Campbell, and Dorst 1978). Farther south, spring migration along the California coast begins in the latter half April and extends through early May, with most migration apparently during daylight and with some tendency for the birds to migrate in pairs. By early May the birds begin arriving in southeastern Alaska, and they move east along the arctic coast of Alaska by the first week of June. Nesting areas of northern Alaska are reached by the second or third week of June. There is some limited evidence of an overland migratory route from the arctic coast to the southwestern shore of Hudson Bay. The fall migration begins in late August, with the first arrivals appearing in California in September and large numbers passing the coastline of northern California as late as mid-November (Palmer 1962).

### Social Behavior

**MATING SYSTEM AND TERRITORIALITY.** All the evidence suggests that this species exhibits monogamous mating, sustained or renewed annually to produce essentially lifelong pair bonding. Sjolander (1978) found that banded birds remained paired for at least several years. Davis (1972) observed a very high incidence of territorial stability from year to year, suggesting such permanent pair bonding as well as a high level of territorial site tenacity. The age of initial pair bonding is still unknown, although Lehtonen believed that in Finland these birds take up territories when 5 or 6 years old but do not actually lay eggs until the following year, when they are 6 or 7 years old. Thereafter most birds breed

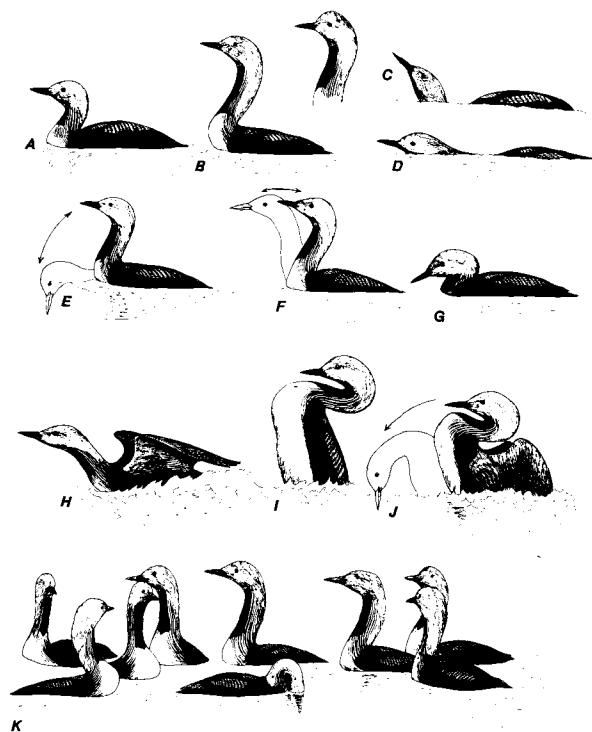
every year (Lehtonen 1970). Sjolander (1978) doubted that such a long period before breeding is typical.

The birds are strongly territorial, and Davis (1972) has found that these territories are used for copulation, nesting, brooding, and feeding of young as well as for other general adult activities. The territories often encompassed more than one pond, with the nonnesting pond used for escape, resting, and feeding of young. Territory sizes averaged (for 35 territories) 3.66 hectares in the three years of Davis's study, with a range of 1.125 to 9.54 hectares. Smaller territories appeared to be less productive of young than larger ones, although statistical significance was lacking. These territories are far smaller than those that have been estimated in Scandinavia, where large and relatively deep lakes are typically used and where breeding on lakes of less than 10 hectares is extremely rare (Dunker and Elgmark 1973). Lindberg (1968) estimated that 16 territories in Sweden averaged 212 hectares, and Lehtonen (1970) judged that territories in Finland ranged from 100 to 150 hectares. Dunker (1974) estimated that 12 territories in southern Norway ranged from 43 to 96 hectares, and the average of 9 was 64 hectares. Within these 9 territories, most of the birds' surface and foraging activities were in areas no more than 15 meters deep, and such areas appear to be a critical foraging component of territories in these relatively deep lakes.

**VOICE AND DISPLAY.** Various persons have described displays and calls of this species, but the observations of Sjolander (1968, 1978, summarized by Cramp and Simmons 1977) are probably most useful and comparable to those of other species. Sjolander recognized seven call types of adults plus two intensities of chirping contact calls of chicks. Adults of both sexes utter a croaking call that is long, pulsed, and hoarse, lasting several seconds, similar to a repeated raven (*Corvus corax*) call. It is sometimes used in territorial encounters, during antiphonal calling by the pair, and also during disturbance. A wolflike wailing call consisting of two or three notes of increasing volume and pitch is uttered during territorial encounters and also between neighboring territorial pairs. In 6 ascertained cases it was uttered by a male. A yodel or long call, lasting a second or more and consisting of a short, weaker note and a longer, higher-pitched note, is the major territorial call. It is often repeated, with yodellike breaks between calls. This is the loudest of the calls, and in 18 ascertained cases it was performed by the male of a pair. A similar short yodeling is sometimes also uttered. A short call or "kuik call," with a rising inflection, precedes a splash dive and is uttered by both sexes. Both sexes also utter a low contact call that sounds like human humming. Finally,

a somewhat louder moaning call is used as a contact note toward the mate or young and is characterized by a sudden rise in pitch in the middle.

Displays of the arctic loon have been thoroughly described by Sjolander (1978) and also by Dunker (1975); Sjolander's terminology is generally adopted here. During normal swimming (fig. 31A) the neck is only moderately raised, but in the raised neck display it is greatly extended, with the neck feathers sleeked (fig. 31B). This posture is adopted by both sexes and by young from 2 weeks old. A high-front variant is similar (fig. 31B, inset) but the neck feathers and crown feathers are more ruffled. During "flattening" (fig. 31D) the bird stretches out on the water with much of the body submerged. When the bill is held very near the water this appears to be an escape or fear-associated response, while a similar posture characterized by a distinctly uptilted bill (fig. 31C) seems to serve as an aggressive display ("*niedrige Angriffsstellung*" of Lehtonen 1970). Bill dipping is often performed from a high front or raised neck posture (fig. 31E), and in nonsocial situations it grades into normal peering behavior. A combination of bill dipping,



31. Social behavior of the arctic loon (mainly after Sjolander 1978): A, normal swimming; B, raised neck and raised neck with crown raising; C, bill tilting in flattened posture; D, flattened posture; E, bill dipping; F, jerk swimming; G, short neck posture; H, rushing; I, fencing; J, bow jumping; K, circle dancing.

neck stretching, and head nodding characterizes "jerk swimming" (fig. 31F), which is usually performed by two birds approaching one another. In the short neck posture (fig. 31G) the bill is lowered toward the breast and the neck appears very thick. It is used by females before copulation and by males when showing a nest site. Probable primary threat displays include splash diving (by both sexes) and rushing (fig. 31H) over the water, often in rapid pursuit of another bird. However, rushing sometimes has also been observed in connection with apparent courtship. Other intensely aggressive displays are fencing (fig. 31I) in an upright posture while treading water and bow jumping (fig. 31J), a rapid alternation of bill dipping and an upward jump while fencing, with or without associated wing spreading. At times a "penguin dance," which is apparently a low-intensity form of bow jumping without the associated bill dipping, has been observed. Finally, in circle dancing (fig. 31K) two or more birds approach one another in a raised neck or high front posture and begin circling a common center point. As many as 32 birds have been seen participating in such circle dances, and up to four revolutions have been observed. This display appears to be a ritualized threat behavior. Other behaviors, such as "mock sleeping" and "rolling preens," are only questionably ritualized into signals, though they sometimes occur during social display.

Copulation is preceded by "search swimming" by the female; she swims close to shore in a pronounced short neck posture, typically following this with "going ashore," and lying down while remaining in her short neck posture. These behaviors are the only ones that consistently precede copulation, although jerk swimming is also fairly frequently performed (Sjolander 1978). The mechanisms of actual pair formation are obscure in this and other loon species, though Dunker (1975) believed that social display in flocks may serve as a kind of premating courtship and may help to synchronize as well as induce pair bonding. He noticed that the highest incidence of spring-to-fall flocking occurs in August, when territorial calling is at a low incidence and when a good deal of circle dancing may be seen. However, Sjolander (1978) questioned the possible sexual significance of such social interactions during flocking and regarded the major purpose of late-summer flocking as foraging. He believed that pair bonding might occur in spring, when mate-seeking females visit territories.

## Reproductive Biology

**BREEDING SEASON AND NESTING SUBSTRATE.** Peterson (1979) reported that nesting in the Yukon-Kuskokwim delta area of Alaska began about a week after the peak

arrival of pairs on ponds, with 50 percent of the nests begun by June 9, 11 days after peak arrival. All clutches were completed during the period June 4–22. Davis (1972) stated that arctic and red-throated loons arrived on the Hudson Bay coast during the first week of June and moved to inland breeding ponds as these thawed. Nest building began as shoreline nesting areas emerged from spring floodwaters, with nest building and egg laying beginning a day or two later. In one year this occurred in mid-June, and in another in late June. Seven egg dates for Ontario range from June 23 to July 4 (Peck and James 1983). On Victoria Island the birds appear by mid-June, and eggs may be laid as early as June 19 (Parmelee, Stephens, and Schmidt 1967). Lehtonen (1970) found that in Finland nesting began 5–20 days after initial occupation of the territory.

Davis (1972) has analyzed the characteristics of nesting ponds of this species, which were summarized earlier. He found that island sites were preferred to shoreline locations, and this characteristic also has been found typical in Alaska (Bergman and Derksen 1977), Sweden (Lindberg 1968; Sjolander 1978), and Finland (Lehtonen 1970). Island sites appear to be more successful than shoreline sites, perhaps because they are less accessible to foxes. Bergman and Derksen (1977) found that islands used by arctic loons for nesting averaged larger than those used by red-throated loons (106.9 vs. 4.1 square meters) and were usually of land substrate rather than islandlike platforms of vegetation. However, Peterson (1976, 1979) found that among 79 nest sites the use of shoreline and island locations did not differ significantly. She reported average distances of 297 and 386 meters between neighboring nests in two different years.

**NEST BUILDING AND EGG LAYING.** The nest site is apparently selected by the male in this species (Sjolander 1978; Lehtonen 1970). Davis (1972) found that arctic loons that nest on wet substrates construct a nest platform of mud and aquatic vegetation, while nests on dry substrates are simply scrapes on flat ground, with the weight of the bird's body forming a shallow depression. Eggs are normally laid at two-day intervals, and the normal clutch is two eggs. However, Lehtonen (1970) noted that among 85 clutches there were 12 single-egg clutches and 2 three-egg clutches, or an average clutch size of 1.88 eggs. He also noted a range in laying intervals of from 2 to 7 days. Seven of 85 clutches were replacements in his study. Davis (1972) found an average clutch size of 1.74 eggs for 91 clutches exclusive of re-nesting attempts, the number of which were not specifically noted. Peterson (1976, 1979) found an average clutch size of 1.93 eggs for 43 nests and did not mention any possible re-nesting efforts.

**INCUBATION AND BROODING.** Both sexes incubate, though most is done by the female (Lehtonen 1970). Davis (1972) concluded that two-egg clutches were less likely to be lost than one-egg clutches, and even when birds with two-egg clutches lost one egg the remaining one had a higher probability of survival than did eggs from single-egg clutches. In his study area the major predators were birds, especially parasitic jaegers (*Stercorarius parasiticus*). He concluded that two-egg clutches are advantageous for arctic and red-throated loons because of the occasional raising of the second chick in broods of two and the better chance of hatching at least one. He regarded the immediate onset of incubation and the resulting staggered hatching period as an adaptation ensuring that one of the two chicks would have an advantage in feeding competition with its sibling and increasing the probability that at least one chick would survive to fledging. Sjolander (1978) determined a 27–29 day period between the laying of the second egg and the hatching of the first. He observed that the empty shells were carried out on the water and dropped away from the nest after hatching, an adaptive behavior since the nest is then used for brooding for several days.

**GROWTH AND SURVIVAL OF YOUNG.** Davis (1972) found that young arctic loons had a higher survival rate than young red-throated loons at his McConnell River study site, owing to better survival of the first-hatched chick in each nest as well as to increased survival of the second-hatched in nests hatching both eggs. His overall estimated rate of chick survival was 56 of 90 hatched chicks, or 62 percent. Lehtonen (1970) reported that 34 out of 72 hatched young survived to fledging, or 47 percent. The fledging period of chicks in the wild was estimated at 59 to 64 days by Lehtonen (1970) and at 46 to 53 days by Parmelee, Stephens, and Schmidt (1967). Sjolander (1978) observed that a 62-day-old chick was unable to take off in calm weather, though a 72-day-old bird flew without apparent difficulty. He also observed that the chicks remained on the nest the first day after hatching, and they were fed in decreasing amounts on the nest during the first 4 days. Brooding on the water was first seen at 2 days, with each parent typically taking a single chick under its wing. The young were fed not only until they fledged but also considerably beyond, with the latest observed feeding being of a 91-day-old juvenile. The earliest age at which successful food catching was observed was 36 days. The chirping calls of the young gradually developed into a garbled version of wailing; croaking was initially heard at 55 days and the low call at 64 days. The juveniles remained in their parents' territory until the autumn migration, or 124 days of age. However, after 90–100 days parental con-

tact became limited, and by about 80 days of age most young began sleeping away from their parents.

#### BREEDING SUCCESS AND RECRUITMENT RATES.

Lehtonen (1970) reported that 34 young were fledged from a total of 159 eggs laid in his study area, representing a breeding success of 22 percent. These were produced from 85 nests, a production rate of 0.40 young raised per nesting pair. Davis (1972) reported a hatching success of 94 eggs out of 138 (68.1 percent) and a rearing success of 62 percent, for an overall breeding success of 42.2 percent. With an average clutch size of 1.74 eggs, the resulting production rate should be approximately 0.73 reared young per nesting pair, exclusive of any re-nesting efforts. Nilsson (1977) estimated that arctic loons have an annual adult survival rate of about 89 percent and that a breeding success rate of 0.4–0.5 fledged young per pair would be needed to maintain the population. Nordstrom (1962, 1963) also estimated from banding recoveries a high survival rate and an average life expectancy of more than 8 years for birds 2 years old or older. There are still no good data on recruitment rates for this or any other species of loons, or any direct evidence as to when sexual maturity is attained and breeding begins.

#### Evolutionary History and Relationships

See the account of the red-throated loon for a discussion of the evolutionary history of this species.

#### Population Status and Conservation

There are no population estimates available for this species, either for North America or for the larger world range. Like the other loons, it is relatively vulnerable to oil pollution on migration and wintering areas; a summary of thirteen oil spills tabulated by Clapp et al. (1982) included 197 arctic loons among a total of 41,431 oiled birds, or 0.47 percent of the total. King and Sanger (1979) assigned an oil vulnerability index of 58 to the species. It should be possible to obtain good estimates of the North American arctic loon populations by winter surveys along the Pacific coast from southern Alaska to Baja California, but such figures do not seem to be available, perhaps because of the difficulty of identifying loons in winter. The summer population of arctic loons on the 95,000 square kilometer National Petroleum Reserve was in the vicinity of 28,000 birds in the late 1970s (King 1979), suggesting a breeding season density of about one bird per 4 square kilometers. If this is a typical density the arctic loon is almost certainly the most abundant of all the loon species, with a probable world population in the millions.

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## Common Loon (Great Northern Diver)

*Gavia immer* (Brünnich)

OTHER VERNACULAR NAMES: Islom (Danish); plongeon imbrin (French); Eistaucher (German); himbrimi (Icelandic); shiroeri ohamu (Japanese); gagara (Russian); somorgujo comun (Spanish); islom (Swedish).

#### Distribution of Species (See Map 3)

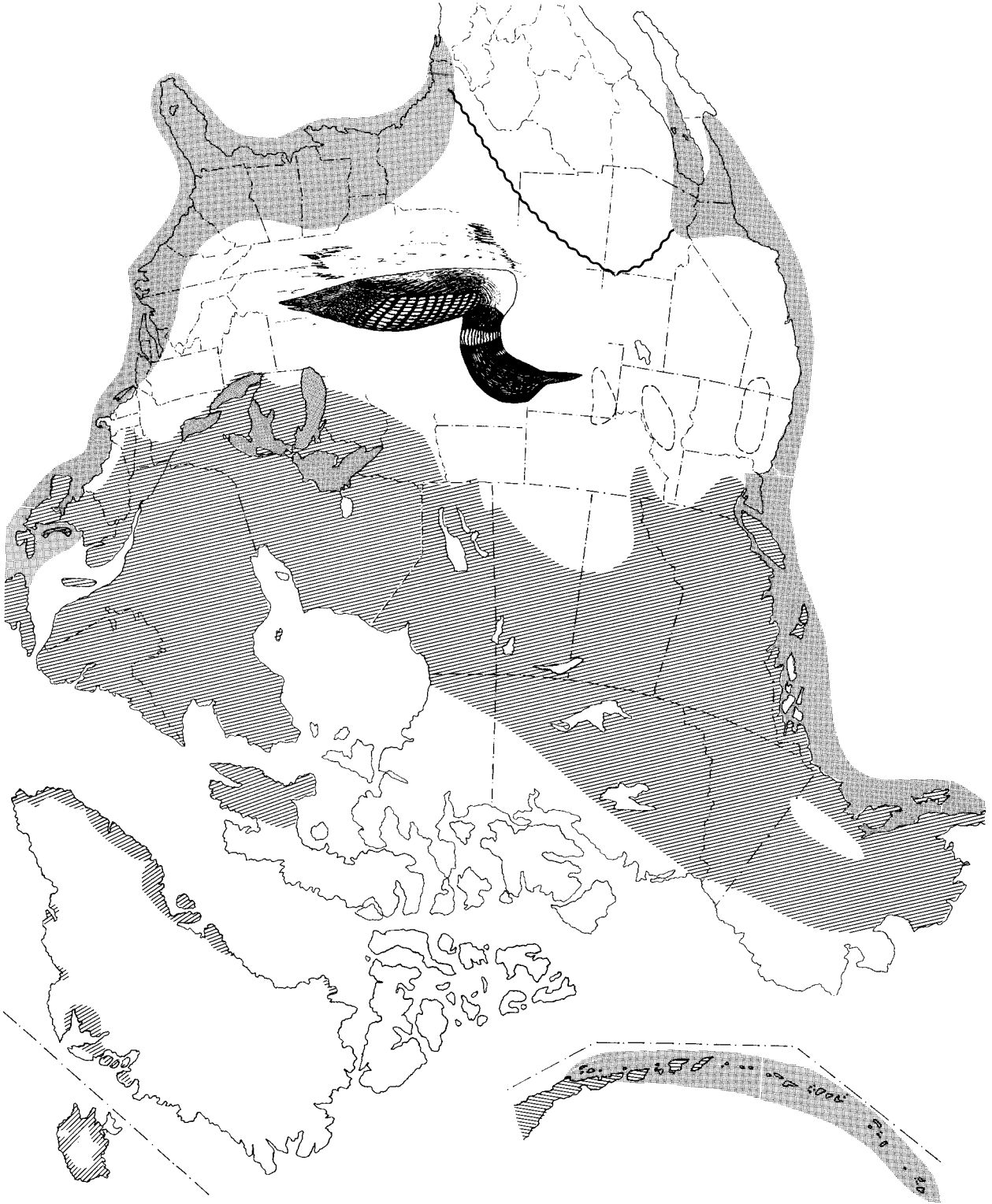
BREEDS from western and central Alaska (Seward Peninsula, Aleutian Islands, and the Brooks Range), northern Yukon, northwestern and southern Mackenzie, central Keewatin, northern Manitoba, northern Ontario, southern Baffin Island, Labrador, and Newfoundland south to northern California (at least formerly), northwestern Montana, western Wyoming, northern North Dakota, southern Minnesota, Wisconsin, Michigan, southern Ontario, New York, Vermont, New Hampshire, Maine, and Nova Scotia; also along both coasts of Greenland, Iceland, Scotland (in 1970), and (probably) Bear Island. Formerly bred to Iowa, Indiana, Ohio, and Pennsylvania.

WINTERS in North America primarily along the Pacific coast from the Aleutians south to Baja California and Sonora, and along the Atlantic and Gulf coasts from Newfoundland south to southern Florida and west to southern Texas; and in the western Palearctic along the Atlantic coast south to northwestern Africa.

#### Description (modified from Witherby et al. 1941)

ADULTS IN BREEDING PLUMAGE (sexes alike). Whole head and all of neck velvety black, slightly glossed green on back of head, neck, and throat and with mauvish tinge on sides of head, lower part of throat and entire neck much more strongly glossed greenish purple; in middle of throat a prominent line of short white parallel vertical streaks, on each side of lower neck a similar line of longer streaks not quite meeting in center of throat or back of neck; mantle black glossed greenish and thickly spotted with white, each feather having a pair of subterminal spots of more or less square shape, those on upper mantle very small, becoming large on lower mantle and still larger on scapulars, back, and rump with very small spots but upper tail coverts unspotted; breast and belly white, sides of upper breast glossy black streaked white, feathers being much like those forming white streaks on neck; flanks as upperparts, feathers with small white spots and those nearest breast streaked with black and white, with

3. Current North American distribution of the common loon; symbols as in map 1. Peripheral or casual breeding areas are shown by a broken line.



white subterminal spots, or edged with white; under tail coverts brownish black tipped white; axillaries and under wing coverts as winter but central streaks darker; tail feathers (rectrices) glossy black with no white tips; primaries and secondaries as winter but outer webs and tips black glossed purplish; innermost secondaries with white spot on outer webs; primary coverts as primaries; wing coverts as rest of upperparts but not quite so glossy, greater coverts sometimes with a second pair of duller white spots.

**WINTER PLUMAGE.** Forehead, crown, and back of neck dark brown, feathers of neck somewhat downlike and whitish bases often ill concealed; whole of rest of upperparts dark brown, feathers margined grayish brown to gray; outermost underscapulars with dull white edges or white subterminal bands; between nostrils and eye feathers brown; tipped white; under eye, chin, throat, and rest of underparts white, but feathers along sides of neck tipped brown, giving somewhat mottled appearance, feathers of sides of lower throat and upper breast with brown centers and white edges, giving somewhat streaked appearance; sides of breast and flanks brown, some feathers with white outer webs and edges; across vent narrow band of brown; under tail coverts brown, broadly tipped white; axillaries white with dark brown median streaks; under wing coverts white, lower ones with pale brown median streaks; tail feathers dark brown, tipped white; primaries and secondaries with blackish brown tips and outer webs, dark brown shafts, paler brown inner webs; wing coverts as rest of upperparts but many lesser with small ill-defined whitish subterminal spots and innermost sometimes with white subterminal bars.

**JUVENILES.** Much like adult winter but edges of feathers of upperparts paler gray and more prominent (feathers more rounded, less square tipped than in adult and gray margins more even); under eye, ear coverts, and sides of neck more finely streaked brown; throat more or less finely streaked or freckled brown; flanks paler brown; axillaries with paler brown and broader median streaks; under tail coverts brown, tipped grayish brown instead of white as adult; tail feathers tipped pale brown instead of white.

**DOWNY YOUNG.** First down rather short, thickly covering whole body and especially thick on underparts. Upperparts dark mouse brown, whole chin, throat, and foreneck grayish brown, all around breast and belly brownish gray shading to white that covers whole of center of underparts. Second down like first but decidedly paler on upperparts. Iris reddish brown, legs and feet dark gray, bill dark gray to dusky (Fjelds  1977).

## Measurements and Weights

**MEASUREMENTS.** Wing (unflattened): males 339–81 mm (average of 10, 360.9); females 315.8–360.0 mm (average of 10, 337.9). Culmen: males 72.5–90.1 mm (average 81.5); females 73–86 mm (average 79.9). Eggs: average of 20, 90.9 x 57 mm (Palmer 1962).

**WEIGHTS.** Adult males (all seasons) 2,200–6,100 g (average of 12, 3,523); females (all seasons) 1,468–5,662 g (average of 13, 2,677) (various sources). Estimated egg weight 167 g (Sch nwetter 1967). Newly hatched young weigh 52–95 g (Fjelds  1977).

## Identification

**IN THE FIELD.** In breeding plumage this species is likely to be confused only with the yellow-billed loon, and distinguishing features between the species are outlined in that species' account, although the simple combination of black bill and white neck collar should suffice for birds in breeding plumage. Birds that are not in breeding plumage are more difficult. Its large size and relatively heavy, tapered bill help to separate the common loon from the arctic and red-throated loons, though distinction from the arctic loon is more difficult. A pale "eyebrow" area is usually present in the common loon in this plumage, but not in the arctic loon. Compared with the common loon, the yellow-billed loon in nonbreeding plumage has much paler throat flecking and fore-neck coloration, the sides of the neck and posterior auricular (ear covert) area are much paler, there is a more distinct "eyebrow," and the mantle area is more strongly cross-banded and generally paler throughout. When swimming, common loons tend to hold the bill more level, rather than uptilted, and the bill itself retains a dusky culmen ridge for most of its length.

**IN THE HAND.** Wing length and culmen length measurements readily separate this species from all others except the yellow-billed loon. The common loon always has a variably dark bill, which ranges from entirely blackish in breeding plumage to one that is variably paler in younger and nonbreeding birds, but the culmen invariably has a dusky culmen ridge along its entire length. Nearly all bill measurements of the common loon and *adamsii* exhibit considerable overlap, but as noted in the account of the yellow-billed loon the forward extension of forehead feathers relative to the tubercle in the middle of the nostril (typically beyond in *adamsii* and barely reaching the tubercle in the common loon) and the forward extension of feathering in the chin (reaching a point directly below the nostrils in *adamsii* but not in the common loon) provide simple

and useful distinctions. Furthermore, the color of the primary shafts in *adamsii* is invariably paler, varying from white to yellowish brown, while in the common loon the shaft color is dark brown. Another useful distinction is that in *adamsii* the two rami of the lower mandible are completely fused, often forming a bulge at the point of fusion, while in the common loon the two rami show a distinct groove along their path of fusion (Burn and Mather 1974). Finally, though the feature may be of limited use, the eye of the common loon reportedly is slightly larger than that of *adamsii*, especially in height, with the proportionate difference greater than in bill measurements (Binford and Remsen 1974).

### Ecology and Habitats

**BREEDING AND NONBREEDING HABITATS.** McIntyre (1975) analyzed the use of lakes by breeding loons in Minnesota to try to determine essential or optimal habitat features, primarily including lake size, the presence of nesting islands, and human disturbance factors. She found that very few lakes smaller than 10 acres (4 hectares) supported territorial pairs, but that nearly all lakes larger than 50 acres (20.2 hectares) had territories. Few pairs on lakes smaller than 25 acres (10.1 hectares) successfully raised young, and none of these raised two-chick broods, but over half of the pairs on lakes larger than 50 acres raised young. She also found that adding artificial nesting islands to lakes without them did not significantly enhance the value of those lakes to loons, though the presence of islands did influence nest site choice. Recreational use of lakes was found to have no effect on the choice of a lake for territorial use by loons, and no direct evidence was found that recreational use had an adverse effect on loon productivity. Only on small lakes having intensive recreational use was a decline in two-chick broods evident. Water clarity and associated prey visibility were not directly tested, since all the lakes studied were eutrophic, and McIntyre concluded that the ultimate factor in breeding habitat selection by common loons may be lakes with an abundant supply of small fish as well as water clear enough to allow efficient foraging. Small, eutrophic lakes are used provided these conditions exist and shoreline development and recreational use are kept at a minimum. Trivelpiece et al. (1979) found that loons in Adirondack Park used public lakes less than private ones, with nearly 50 percent of the breeding pairs occurring on public lakes accessible only by trail or on private estates with restricted usage. Vermeer (1973) similarly reported an inverse correlation between the amount of human disturbance and the numbers of breeding loons, as well as a positive correlation between

numbers of breeding loons and the presence of islands for nesting in Alberta lakes. Sawyer (1979) noted a reduction in breeding loons in wildlife management units of Maine with a high degree of recreational development, and similar trends in other areas (New Hampshire, Wisconsin, etc.) have been attributed to increasing human disturbance.

Nonbreeding habitats consist of coastal areas, especially bays, coves, channels, inlets, and other shallow sites, and also lakes or reservoirs, less commonly rivers. Information in table 5 suggests that the highest coastal densities occur in bays and that deeper waters are little used at any season. In studies along the Virginia coast, McIntyre (1975) found that wintering loons feeding during flood tide were in deeper waters and those feeding during ebb tide were in shallower water, apparently feeding on prey species that lagged behind the receding tide. Thus loons stayed in place or even moved closer to shore during ebb tides. Most feeding depths were from 6 to 15 feet, comparable to depths observed during summer. During migration in spring almost any open waters seem to be used, especially ice-free rivers or lakes with river inlets. Fall stopover sites appear to be traditional lakes along the migratory routes.

**SOCIALITY AND DENSITIES.** Breeding densities of common loons are quite variable (table 37), apparently depending on general habitat suitability for breeding, but in all cases typical densities are appreciably lower than those reported for red-throated loons and arctic loons. This certainly is in part a measure of the larger body size and increased food requirements for breeding common loons. Barr (1973) estimated that a loon pair and two chicks eat about 1,050 kilograms of fish during a 15 week breeding season, and thus food supplies are likely to place an upper limit on breeding density in most areas. The actual territory size is difficult to measure in most cases, but Minnesota studies suggest that territories often center on islands, with a minimum territorial requirement of 100–200 acres (40–80 hectares) per pair. Many pairs that occupied small lakes used an adjacent small lake for supplementary foraging, and although they were not observed defending the second lake it may also have been part of the breeding territory (McIntyre 1975). Olson and Marshall (1952) judged that 52 territories they studied ranged from 15 to more than 100 acres, and they invariably included a suitable nesting site and an area of open water for foraging, escape, display, and loafing.

**COMPETITORS AND PREDATORS.** Except for a possible small degree of breeding contact between the common loon and the yellow-billed loon, it seems unlikely that any other loon species provides any significant degree of

Table 37: Average Breeding Densities and Production Rates for Common Loons

	New Hampshire, <sup>a</sup> 1976–77	Minnesota, <sup>b</sup> 1972, 1976	Minnesota, <sup>c</sup> 1975–76	Saskatchewan, <sup>d</sup> 1973–74	New York, 1977–78
Territorial pairs	89	25.5	73	99	80.5
Water area (ha)	44,739	1,098	5,304	3,847	28,229
Hectares per territorial pair	502.9	43.7	72.7	39.0	350.6
Total young fledged	43.5	7.5	35.5	53	67.5
Young fledged per territorial pair	0.48	0.29	0.49	0.53	0.84
Hectares per fledged young	1,048	151	148	74	417

NOTE: Adapted from tabular material in Trivelpiece et al. 1979.

<sup>a</sup>Hammond and Wood 1977. <sup>b</sup>McIntyre 1978. <sup>c</sup>Titus 1979. <sup>d</sup>Yonge (cited in Titus 1979).

competition with the common loon. Reimchen and Douglas (1980) reported only rare interactions between common and red-throated loons during summer on a lake in the Queen Charlotte Islands, and when interactions occurred the common loons were dominant except when the red-throated loons were close to shore.

Few if any predators attack healthy adult common loons, but eggs and young are taken by a large number of predators. McIntyre (1975) saw American crows (*Corvus brachyrhynchus*) eating loon eggs and judged from track evidence that raccoons (*Procyon lotor*) and skunks (*Mephitis mephitis*) might be significant mammalian predators of nests. Olson and Marshall (1952) were usually unable to determine the causes of nest predation in their studies, but they judged that at least crows, minks (*Mustela vison*), and muskrats (*Ondatra zibethicus*) might have been in part responsible. Fox, Yonge, and Sealy (1980) determined that 82 percent of the egg predation they observed resulted from herring gulls (*Larus argentatus*) and common ravens (*Corvus corax*), and minks were the only mammalian nest predators they identified. Chick losses are sometimes fairly high, but such factors as starvation, freezing, and other nonpredator dangers are probably more often direct causes of chick mortality than is predation on healthy chicks. Olson and Marshall (1952) reported one case of a chick taken by a large northern pike (*Esox lucius*). In general the loss of eggs to predators seems a rather secondary cause of breeding failure in common loons (table 32).

### General Biology

**FOOD AND FORAGING BEHAVIOR.** There are few comprehensive studies of foods and foraging in this species. Madsen (1957) was able to study only 3 specimens from

coastal waters off Denmark in winter, and he found only fish remains. He summarized the available information on the species' diet and listed the previously reported prey species, of which codlike forms (*Gadus* spp.), sculpins (*Cottus* spp.), herrings (*Clupea* spp.), gobies (Gobiidae), and flatfish (Pleuronectidae) seem to figure prominently. Cramp and Simmons (1977) have summarized more recent European literature, and Palmer (1962) has done the same for North American sources. The North American literature includes more freshwater fish than does the European information, and most of these are nongame varieties. Barr (1973) studied the feeding biology of common loons in the oligotrophic lakes of Algonquin Park, Ontario, and concluded that common loons are facultative predators of fish and crustaceans and select the most readily available prey species, mainly in the size range of 5–20 centimeters. In that area the yellow perch (*Perca flavescens*) was most commonly taken, with coregonids of secondary importance. Stomach contents of 27 loons from Ontario and the Great Lakes states included yellow perch and representatives of at least six other fish genera as well as unidentified cyprinids and catostomids (Olson and Marshall 1952).

Foraging is performed by extended dives and underwater chases, their length probably depending upon such variables as water depth, density, size, and elusiveness of prey, and possibly other variables. Mean diving times from various areas range from 34.0 to 64.4 seconds (Reimchen and Douglas 1980), which certainly is well below the species' reported capabilities for prolonged underwater submersion (tables 11 and 12). Reimchen and Douglas (1980) reported a success rate of 50.8 percent on 187 foraging dives, with sticklebacks (*Gasterosteus aculeatus*) the sole prey species they saw taken.



**MOVEMENTS AND MIGRATIONS.** There are probably few if any movements by adults out of their large territories during the breeding season. However, young birds begin to leave their natal lakes when they are 11–13 weeks old and apparently begin to move to larger lakes. McIntyre (1975) found that all but 2 of 23 young birds moved out of their parents' territories when 11–14 weeks old, and the 2 remaining ones remained until they were more than 5 months old. This movement probably normally occurs shortly after fledging and sometimes involves displacements of several miles.

Migration in common loons occurs over a broad geographic front and is much less confined to coastal areas than in the other loons. Fall migration occurs over several months, with departures from interior breeding areas beginning in late August or early September and continuing until freeze-up. The Great Lakes, especially Lake Huron, are a major fall concentration area. There are three major spring migration routes, including a Pacific coastal route, an Atlantic coastal route, and a third route funneling birds from the Gulf and Atlantic coasts through the Great Lakes to northwestern Canada. Early coastal departures begin in mid-March, and peak numbers pass along New England in late May. Many birds have reached their Minnesota breeding grounds by late May, with arrival times partly dependent on thawing periods of the lakes. Early arrivals were birds that occupied territories and consisted either of already paired birds or of males whose mates arrived from a day or two to as much as two weeks later. It thus seems likely that most birds do not retain pair bonds over winter but instead renew them each spring through common territorial fidelity. However, observations in Iceland led Sjolander and Agren (1972) to believe that there the birds are permanently paired, since they arrived on breeding areas as pairs and began egg laying only 5 days later.

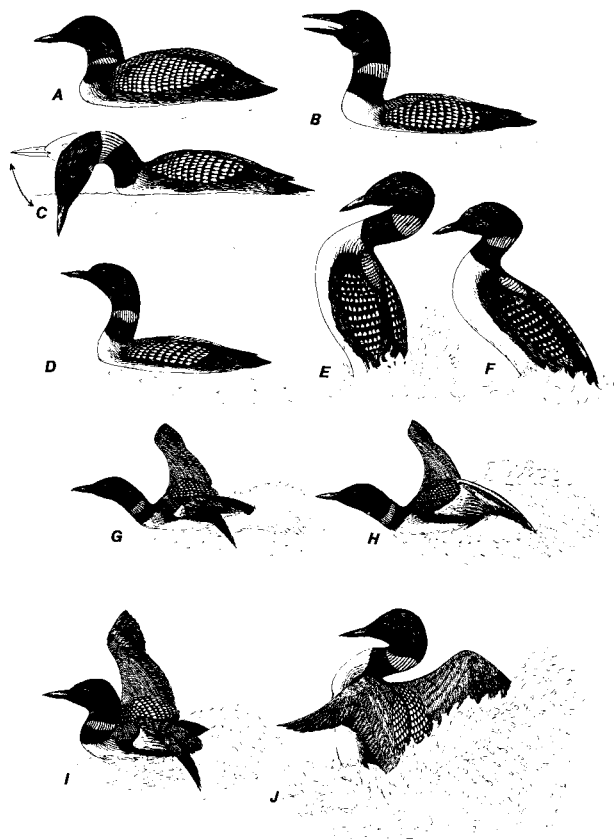
### **Social Behavior**

**MATING SYSTEM AND TERRITORIALITY.** Most authorities agree that the pair bond in this species either is permanent or is renewed yearly as long as both members of the pair remain available, so that probably little actual pair-bonding behavior is necessary in adults after they initially acquire mates. However, birds of either sex that lose their mates may acquire new ones fairly rapidly, and territories that are vacated are often filled immediately (McIntyre 1975), suggesting that a "floater" population of available single birds or even pairs is probably available in at least some areas. McIntyre believed that initial breeding probably does not occur until the birds are over 4 years old, based in part on the

incidence of nonbreeding birds in nuptial plumage on the breeding range. Like other loons, a high degree of territorial fidelity seems typical of this species, though it has not been so well documented as in arctic and red-throated loons. Such territorial site tenacity is indicated by a high use of the same nesting sites from year to year (Olson and Marshall 1952; Fox, Yonge, and Sealy 1980). Territories are established in early spring immediately after males or pairs return to their breeding areas, and the incidence of territorial defense gradually wanes over the summer. Sjolander and Agren (1972) judged that common loon territories are up to 25 hectares in area and, as noted earlier, Marshall and Olson (1952) made similar estimates.

**VOICE AND DISPLAY.** Vocalizations of this species have been described by Sjolander and Agren (1972) and summarized by Cramp and Simmons (1977). Yodeling (or the long call) is the most familiar and variable call, consisting of a prolonged series of notes with sharp breaks, usually with the pitch rising on the third note and undulating thereafter. It is uttered only by territorial birds, especially early in the reproductive cycle. A probable low-intensity version of this is the wail, which sometimes resembles a wolf's howling and is typically uttered during less intense territorial encounters. A tremolo call is produced during agitated disturbance, especially where there may be a tendency to flee; it often functions as a distraction display when uttered as a duet by a pair defending a nest or young (Barklow 1979). It exhibits a high degree of modulation in frequency as well as amplitude and thus has potentially high information content. A moaning call resembling human moaning may be uttered when one adult is searching for its mate or young. It is often repeated at irregular intervals and carries well in spite of its apparent low amplitude. Chicks utter chirping sounds and other high-pitched notes that are still only poorly described.

Displays in common loons have been described by several authors (e.g., Olson and Marshall 1952; McIntyre 1975), but those of Sjolander and Agren (1972) seem most comparable to descriptions of other species, and they have carefully separated territorial displays from courtship. The only behavior other than copulation that these authors interpreted as courtship was a formalized bill dipping followed by mutual splash diving; all the rest were referred to territorial signaling. These displays include neck stretching ("raised neck" posture) (fig. 32D), often with raising of the forehead feathers and sometimes with associated wailing or long calling (fig. 32B), bill dipping (fig. 32C), and splash diving, all of which are very frequently performed. Circle dancing, with two or more birds circling a point while perform-



32. Social behavior of the common loon (after various sources): A, normal swimming; B, calling; C, bill dipping; D, neck stretching and crown raising; E, F, early and late stages of upright or fencing posture; G–J, aggressive rush followed by upright posture with wing raising.

ing neck stretching, bill dipping, and diving, is also a common ritualized form of aggressive behavior during territorial confrontations. More intense territorial displays include the “upright” or fencing posture (fig. 32E,F), in which a penguinlike posture is maintained by treading water, sometimes with wing spreading (fig. 32J) and occasionally with jumps out of the water. This posture is often preceded or followed by long rushes over the water (fig. 32G–I), with the wings opened and flapping. McIntyre (1975) described some additional possible displays, such as jerk diving, “hunched” posture (similar to flattening in arctic and red-throated loons), and others, but these in general do not seem clearly defined as to occurrence or possible functions.

As in other species, copulation is preceded by the female’s search swimming along the shoreline, finally going ashore and crouching down. The male typically follows the female closely and immediately attempts to

copulate. Although special copulation platforms have been mentioned by some authors, they do not appear to be characteristic of the common loon or other loon species (Sjolander and Agren 1972).

### Reproductive Biology

**BREEDING SEASON AND NESTING SUBSTRATE.** In Ontario the records of eggs from 113 nests extend from May 11 to August 25, with 57 records concentrated from June 2 to 23. In a Minnesota study, nest establishment began in early June and peaked June 15–28. Hatching extended over a 16 day period, July 11–26, with the late-hatched nests the result of renesting efforts (Olson and Marshall 1952). Broods have been observed in the Aleutian Islands as early as June 6 (F. Zeillemaker, pers. comm.). McIntyre (1975) found the egg-laying period in Minnesota to extend from May 7 to June 28, with almost half the first nests initiated in the third week of May. Renesting efforts typically are begun 5–14 days after the loss of a nest, whether the first or second effort, and probably average about 10 days. A maximum of three laying cycles was reported by McIntyre (1975). Of 15 replacement clutches, 11 pairs chose new nest sites and 4 used the old site (Palmer 1962). Of 15 sites that had previously been successful, 10 pairs used the same site the following year, while of 32 sites that were unsuccessful, 28 pairs changed their site for the following nesting effort, in McIntyre’s study.

Nest site characteristics have been studied by Olson and Marshall (1952), who noted that for 54 nest locations the major criteria seem to be sheltered locations, availability of small islands, and proximity to open water. Cover density was only of incidental significance, although some kind of vegetative cover was present in nearly all cases. McIntyre (1975) found that proximity to food did not seem to influence nest site choice, but when islands were available 88 percent of all nests were built on them. Lakes with islands also significantly increased the probability of nesting success, though increased distance of the island from shore did not. Vermeer (1973) found that 20 of 26 nests studied were in sites sheltered from wave action, and all but one afforded easy underwater exit by the sitting bird. Nineteen were on islands less than 2 acres in area, and only one was on the mainland. There was a positive relation between the distribution of breeding pairs and of islands and a negative correlation between abundance of breeding pairs and relative human disturbance.

**NEST BUILDING AND EGG LAYING.** Evidently either sex might select the nest site (McIntyre 1975), although

Sjolander and Agren (1972) suggested that the male does this. Certainly both sexes participate in nest building, and McIntyre (1975) observed that one pair spent 4 days between the onset of building and the laying of the first egg of an initial nest; replacement nests may be built more rapidly. Eggs are normally laid at 2 day intervals, and in most cases the clutch is of 2 eggs. Peck and James (1983) reported two-egg clutches for all of 91 Ontario nests, and McIntyre (1975) indicated that 51 Minnesota clutches had an average clutch of 1.67 eggs. There are a few records of two females' laying in the same nest, raising the clutch to 3 or 4 eggs.

**INCUBATION AND BROODING.** Incubation begins with the laying of the first egg and is performed by both sexes, with participation fairly evenly divided, though the male possibly does much of the daytime incubation. There is a very high level of nest attentiveness, the nest usually being left only for territorial defense. McIntyre ascertained four incubation periods to be 26 to 31 days, averaging 27.5. Peck and James (1983) mentioned two nests with incubation periods of 29 days, and likewise Olson and Marshall (1952) reported two nests as having

29 day incubation periods. The eggs typically hatch a day apart, and the chicks usually remain in the nest for a day after hatching. Brooding on the back of the parent begins while the chicks are still in the nest, and they often eat nest vegetation before leaving the nest (McIntyre 1975).

**GROWTH AND SURVIVAL OF YOUNG.** At the time the chicks leave the nest they can make short dives of a few seconds, and they soon begin to beg for food by pecking at the base of the parents' bills. When they are 1 or 2 weeks old they begin to capture some of their own fish, although their efficiency rate is extremely low (Barr 1973). By the time the chicks are 6 to 7 weeks old the adults begin to leave their territories, but they continue to feed their chicks until fledging or until they leave their natal lakes. Fledging probably occurs at about 11 weeks of age, although by 2 months of age the flight feathers are nearly as long as in adults and flight might be possible then (McIntyre 1975). Most brood mortality probably occurs within the week following hatching, and very little occurs after the chicks are about 2 weeks old. Causes of early brood losses are still very uncertain,

Table 38: Reported Reproductive Success Rates in Common Loons

	Minnesota, <sup>a</sup> 1978	Vermont, <sup>b</sup> 1978	New Hampshire, <sup>c</sup> Eight-Year Average	Saskatchewan, <sup>d</sup> Three-Year Average
Lakes reported	59	33	—	1
Lakes with territorial pairs	55	20	54.8	1
Total territorial pairs	68	23	94.9	98.6
Total nesting pairs	55	16	69.1	76
Pairs with known hatching results	50	—	—	76
Total broods hatched (% of nests)	44 (80%)	8 (50%)	49.5 (72%)	39.3 (52%)
Total chicks hatched	65	12	66.8	—
Average brood size at hatching	1.48	1.5	1.5	—
Hatched chicks per nesting pair	1.18	0.75	0.96	—
Hatched broods per nesting pair	0.8	0.5	0.64	0.52
Pairs with known fledging results	46	—	—	—
Total fledged broods	40	—	—	35
Total juveniles fledged	54	12	55.4	53
Brood size of fledged young	1.35	1.5	1.24	1.48
Ratio of fledged/hatched young	0.92	1.0	0.83	—
Juveniles fledged per nesting pair	0.98	0.75	0.79	0.73
Juveniles fledged per territorial pair	0.79	0.52	0.58	0.53

<sup>a</sup>McIntyre 1979. <sup>b</sup>Metcalf 1979. <sup>c</sup>Unpublished data for 1976–83, provided by J. Fair (in litt.).

<sup>d</sup>Fox, Yonge, and Sealy 1980, 1973–75 data.

though predation by fish has been implicated as one possible factor (Olson and Marshall 1952).

#### BREEDING SUCCESS AND RECRUITMENT RATES.

Breeding success rates for this species have been summarized in tables 37 and 38, which suggest that in various studies covering a variety of areas the number of young reared per territorial pair has averaged close to 0.5 (range 0.20–0.84). Common loons seem to have a higher potential for reneesting than the other loon species, but they also require considerably larger breeding areas than do arctic or red-throated loons. Estimates of annual recruitment rates are still lacking, although Zimmer (1982) estimated that Wisconsin's loon population consisted of 40 percent successful breeders, 32 percent unsuccessful breeders, and 28 percent nonbreeders. If this is a reliable statistic, a production of 0.5 per territorial pair would represent a recruitment rate of 12.8 percent. Munro (1945) noted that the late summer population of loons in his study area (possibly including some nonbreeders) was 150 adults to 21 young, or a maximum recruitment rate of 12.2 percent. Such recruitment rates might indeed be typical of the species, based on what is known of adult survival rates in the arctic loon, and some indirect estimates of adult survival (based on a variety of breeding success data) suggest an annual survival rate in the range of 80–85 percent.

#### Evolutionary History and Relationships

See the yellow-billed loon account for a discussion of this topic.

#### Population Status and Conservation

There are still no good continentwide estimates of common loon populations, although several states have now instituted annual breeding surveys. Minnesota probably has the largest breeding loon population south of Canada, possibly numbering as high as 5,000 pairs and representing a fairly stable population. Maine's population is probably next largest and also is apparently stable. It has numbered in the vicinity of 1,100 pairs since the late 1970s and possibly totals about 3,000 birds. In New Hampshire the population rose from 271 birds in 1976 to 363 in 1983, and the Vermont population declined from 56 in 1978 to 34 in 1983. New York supports about 200 nesting pairs, mainly in Adirondack Park, where the possible effects of acid rain have not yet become apparent. Wisconsin's population is approximately 1,300 birds, and about 100 are left in the Upper Peninsula of Michigan. The Montana population is about 125 birds,

and a few pairs probably breed annually in northern North Dakota, northwestern Wyoming, Idaho, and northern Washington. Thus the current population south of Canada is probably no more than 15,000 birds. Increased human recreational use of lakes in prime breeding areas pose problems for loons, as do pesticides (Fox, Yonge, and Sealy 1980), the possible effects of acid rain on prey populations, and water-level fluctuations in reservoirs. However, considerable success has been attained with artificial nesting sites (moored rafts) in areas lacking good natural sites or having extreme water-level fluctuations. Like other loons, this species is susceptible to being caught in fishing nets and has suffered local mortality from botulism (on Lake Michigan). Clapp et al. (1982) reported a loss of 374 common loons among 33,255 birds (1.12 percent) involved in 12 different oil spills. An oil vulnerability index of 47 has been assigned the species by King and Sanger (1979). Recent observations by Alexander (1985) indicate loons may have a serious sensitivity to mercury poisoning as well; perhaps as many as 7,500 birds died in the Saint George Sound area of Florida during the winter and spring of 1983, and most of the birds autopsied showed lethal or near-lethal levels of mercury.

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### Yellow-billed Loon (White-billed Diver)

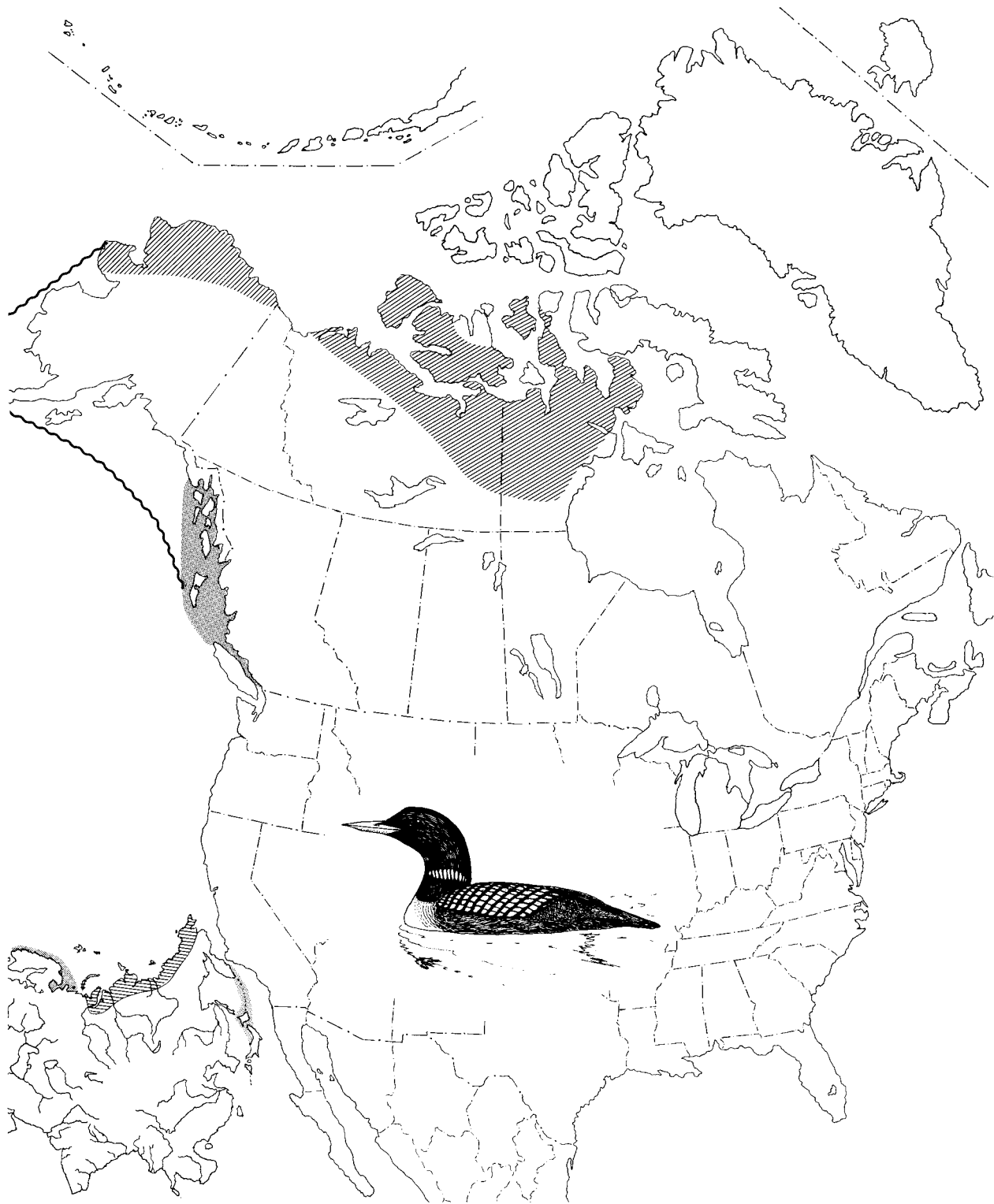
*Gavia adamsii* (Gray)

OTHER VERNACULAR NAMES: Hvidnaebbet lom (Danish); plongeon à bec blanc (French); Gelbschnabel-Eistaucher (German); svabrusi (Icelandic); hashijiro (Japanese); beloklyuvaya gagara (Russian); vitnäbbad islom (Swedish).

#### Distribution of Species (See Map 4)\*

BREEDS in North America from northern and western Alaska (south to Saint Lawrence Island and the southern Seward Peninsula) east to Banks, Victoria, and Prince of Wales islands and northern Keewatin, and south to east-central Mackenzie and east-central Keewatin; and in Eurasia from extreme northwestern Russia east to Siberia (including Novaya Zemlya). Summers

\*This form is considered by some (e.g., Dementiev and Gladkov 1968) to be a subspecies of *G. immer*, and at least in Eurasia the two forms apparently exhibit nonoverlapping breeding ranges. Proof of breeding sympatry in North America is apparently lacking, though there appears to be a broad zone of contact and possible overlap in northern Canada (Godfrey 1966).



4. Current North American distribution of the yellow-billed loon; symbols as in map 1.

outside the breeding range east to northeastern Keewatin (Melville Peninsula) and northern Baffin Island, and south to southern Mackenzie (Great Slave Lake) and southern Keewatin.

**WINTERS** in North America along the Pacific coast of Alaska, casually south in coastal areas to California and extreme northern Baja California, and inland to Alberta; and in Eurasia in the breeding range, casually west to Greenland and south to southern Europe, China, Korea, and Japan.

### **Description** (after Various Sources)

**ADULTS IN BREEDING PLUMAGE** (sexes alike). Similar to that of the common loon, but with a purplish rather than greenish gloss on the throat and neck, fewer and broader white stripes on the throat (6 vs. 12) and half-collars (ca. 10 vs. 18), and larger white markings on the upperparts, especially the scapulars. The white spots on the sides of the rump average smaller, however. The shaft color of the primary feathers is generally whitish rather than brownish. The bill is ivory to pale straw, the legs and feet are dark gray, and the iris is reddish brown. Rectrices usually 18.

**WINTER PLUMAGE.** Similar to that of the common loon but with the face and sides of the head paler, with whitish feathers extending from the cheeks to above the eye, large pale spots on the side of the nape whitish and more contrasting with the darker areas behind, less contrast between the darker upperparts and the underparts, and a more complete pale brown neck collar. The bill is pale cream, with a variable dusky cast over the bases and the sides of both mandibles near the head but the culmen pale (Cramp and Simmons 1977).

**JUVENILES.** Similar to the common loon but with a less definite head and neck pattern, more grayish brown upperparts, with noticeably wider and paler tips to the feathers of the mantle, scapulars, and wing coverts. The iris is browner than in adults and the bill is variable in color, but a pale culmen is typical.

**DOWNY YOUNG.** Similar to the common loon but relatively fuscous, more grayish brown on head, with a nearly white belly, but a drab gray underwing. The bill is also lighter (Fjeldså 1977).

### **Measurements and Weights**

**MEASUREMENTS.** Wing (unflattened): males 366–88 mm (average of 10, 376.4); females 361–87 mm (average of 8, 368.7). Culmen: males 89–97 mm (average of 6, 91.3); females 87.5–96.0 mm (average of 8, 91.1). Eggs: average of 15, 90.45 x 56.4 mm (Palmer 1962).

**WEIGHTS.** Adult males (breeding season) 3,677–6,750 g (average of 15, 4,968); breeding females 4,025–6,350 g (average of 15, 4,759) (various sources). Estimated egg weight 160 g (Schönwetter 1967). Newly hatched young weigh about 85 g (Fjeldså 1977).

### **Identification**

**IN THE FIELD.** The large size of this species makes separation from the red-throated and arctic loons relatively simple in any plumage. In breeding plumage it can be distinguished from the common loon by its entirely yellowish bill, which is somewhat dusky along its culmen ridge to the nostrils or somewhat beyond. The body appears somewhat bulkier and the neck somewhat thicker than in the common loon, and the bill is usually held uptilted. The white collar and patch on the upper fore-neck have broader and fewer white lines, and the white spots on the mantle are fewer and larger, while they are reduced or absent on the upper rump and lacking from the longest upper tail coverts. The white streaks on the side of the chest average wider. In nonbreeding plumage the yellow-billed loon is substantially paler all over, especially on the head, where the only dark areas are the auricular patch and the crown, while the foreneck, sides of the neck, and hindneck are all distinctly paler than in the common loon. The pale “eyebrow” area is more extensive, tending to encircle the entire eye, and the dark auricular patch is likewise somewhat encircled by paler feathering. Even in immature birds the dusky ridge on the upper mandible extends no more than halfway to the tip of the bill (Binford and Remsen 1974). In juvenile or first-winter birds the bill-shape differences that characterize older birds are not developed, but in the yellow-billed loon the upperparts are a paler grayish brown, and the pale tips to these feathers are wider and paler. By the second winter pale areas in the scapular feathers begin to show up; these are larger and more distinct in the yellow-billed loon than in the common loon (Burn and Mather 1974).

**IN THE HAND.** In addition to the general characteristics mentioned above, some measurements are of value in separating common and yellow-billed loons. There is no actual difference in the angularity of the lower bill profile, but the yellow-billed loon is more likely to have a straight or slightly recurved culmen profile. The adult bill averages 9.7 mm (12 percent) longer in exposed culmen length in *adamsii* and is 3.0 mm (13.8 percent) higher at the anterior edge of the mandible, although overlap occurs. However, the bill of *adamsii* is usually more flat-sided and less convex, especially anterior to the nostrils, and the feathers at the base of the upper mandible in *adamsii* apparently always extend several

millimeters beyond the nasal tubercle, while in the common loon they reach no farther than the tubercle (or a millimeter beyond). Further, in *adamsii* the chin feathers extend farther anteriorly, reaching a point below the posterior edge of the nostrils, while in the common loon they end about halfway to the nostrils. When measured relative to the anterior edge of the malar feathering, this distance is generally under 17 mm in the common loon and over 17 mm in *adamsii* (Binford and Remsen 1974; Burn and Mather 1974). According to Cramp and Simmons (1977) there are 20 rectrices in the common loon and only 18 in *adamsii*, although Palmer (1962) lists 18–20 rectrices for the common loon.

### Ecology and Habitats

**BREEDING AND NONBREEDING HABITATS.** Breeding habitats of this species have been variously described as consisting of large tundra lagoons (Bailey 1948), low-rimmed freshwater tundra lakes and rivers (Snyder 1957), and larger and deeper lakes in tundra areas that provide a combination of nesting islands and food (Parmelee, Stephens, and Schmidt 1967). Similarly, Derksen, Rothe, and Eldridge (1981) noted that all their observations of this species in the National Petroleum Reserve of northern Alaska were on deep and open lakes or large, flowing bodies of water. However, Sage (1971) noted that the birds he studied in northern Alaska did not use rivers for breeding, nor did they nest closer to the coast than about 110 kilometers. He believed that neither size of the lake nor its food resources were critical, since long foraging trips seemed to be typical and one nesting occurred on a lake of only about 18 hectares. On a larger lake of 43 hectares nesting also occurred, and on neither of these sites were there any isolated hummocks or islands that might have provided optimum nesting sites. Sage judged that nesting habitat might be influenced locally by contact with common loons at the southern edge of the breeding range of *adamsii*, and it is possible that habitat use is slightly different in Asia, where common loons do not occur and both rivers and coastal areas seem to be favored for nesting. Thus, Portenko (1981) reported that during summer on Wrangel Island the species inhabits large lakes and rivers with deep pools below rapids where feeding opportunities exist. However, the latter sites may simply be used for foraging rather than nesting, judging from his accounts. Shallow to deep tundra lakes or ponds, with low islands or suitable shoreline vegetation, and with a fish supply within easy flying distance, are probably generally typical habitats.

Outside the breeding season the birds are primarily pelagic, usually seen on ice-free waters close to the

breeding grounds, and are rather rarely found on freshwater areas far from the coast.

**SOCIALITY AND DENSITIES.** This species seems to be the most widely dispersed of all the loons, at least on its breeding grounds. Derksen, Rothe, and Eldridge (1981) estimated a summer density of only one bird per 10 square kilometers (or 200 hectares per pair) in one study area of the National Petroleum Reserve. In aerial and ground surveys of 42,000 square kilometers of coastal habitats of the National Petroleum Reserve, average loon densities during 1977 and 1978 ranged from 0.6 to 1.7 loons per square kilometer, with *adamsii* composing about 15 percent of the total population, or 0.09–0.13 bird per square kilometer (King 1979).

**COMPETITORS AND PREDATORS.** It is certain that this species has widespread breeding contact with the arctic loon and red-throated loon, and it is probable that local contacts also occur with the common loon in North America. However, it is easily the largest of the loons and should be able to dominate these other species socially. Too little is known of its foods to judge possible foraging overlaps among these species.

Nest predation, perhaps by foxes (*Alopex*?), has been reported by Sage (1971), and it seems likely that predation is most apt to be a problem during the nesting phase of the life cycle. Parmelee, Stephens, and Schmidt (1967) judged that adult loons have few natural enemies, though Eskimos kill a few. They judged that entanglement in fishing nets is a significant source of mortality in fledged birds.

### General Biology

**FOOD AND FORAGING BEHAVIOR.** Relatively little is known about the food of this species. Cottam and Knappen (1939) reported on a small sample of 4 birds (summarized in table 13), for which various genera of Cottidae constituted most of the identified food. Bailey (1922) noted that a specimen from Alaska had been feeding on rock cod (*Sebastes*). Otherwise there is little definite information. Sage (1971) observed that the only apparent food fish in one Alaskan nesting lake was the stickleback (*Pungitius*), although nearby lakes held grayling (*Thymallus*). Sage observed that a pair with young exhibited intensive foraging behavior at about 9:00 A.M. and again in late afternoon and early evening. Members of this pair flew up to 5 kilometers from their nesting lake to forage, and he judged that on one occasion a bird might have flown as far as 30 kilometers to feed. Foraging dives on various nesting lakes that he observed averaged about 62–65 seconds, but sometimes the birds remained submerged as long as 90 seconds.

**MOVEMENTS AND MIGRATIONS.** Very little is known of the seasonal migrations of this species, which spends most of the year at sea, well away from most human contacts. Certainly during spring the birds move northward along the Bering Sea coastline, past Point Barrow, and then eastward along the arctic coasts of Alaska and Canada. They remain offshore on open leads until the breeding waters become ice-free (Sage 1971). However, surveys of the eastern Bering Sea and Gulf of Alaska have so far indicated only very low densities of the species, mainly in bays and areas within the continental shelf (see table 5). On Victoria Island the birds arrive by early to mid-June, and some probably remain until well into September, depending upon ice conditions (Par-melee, Stephens, and Schmidt 1967). Presumably most of the North American breeding population winters in waters off the coast of British Columbia and southern Alaska, but there is no good documentation of this. Likewise, there is little evidence of a major overland migration of birds from Pacific coast wintering areas across Alaska or the Yukon, though there are some spring records for birds in the vicinity of Fort Simpson on the Mackenzie River.

### **Social Behavior**

**MATING SYSTEM AND TERRITORIALITY.** There is no reason to believe this species differs from the other loons in its mating system, namely monogamy with pair bonds presumably reestablished yearly. Sjolander and Agren (1976) suggested that a lifelong pair bond may be present in this and all other species of loons. Sage (1971) noted that on one lake where a pair with a brood had been found in 1969 he observed nests in exactly the same location during the next two summers. This suggests a strong site tenacity in the species, as is also typical of other loons. Sage believed that the same individuals return to each lake to breed in subsequent years, supporting the idea of a potentially permanent monogamous breeding system. Sizes of territories have not been carefully estimated for this species, but a breeding dispersion at least as great as that of the common loon is evidently typical, and pairs are separated by at least 600 meters (Cramp and Simmons 1977). Parmelee, Stephens, and Schmidt (1967) found two pairs of loons nesting on a single lake that was about 1.5 miles long, with the birds nesting on islands at opposite ends of the lake. Sjolander and Agren (1976) reported that the smallest lake on which they found nesting birds was about 20 hectares, and the areas of 10 of 14 measured nesting lakes ranged from 30 to 50 hectares. The greatest distance from a nest where the bow jumping display was seen used against an intruder was over 400 meters.

**VOICE AND DISPLAY.** According to Sjolander and Agren (1976) the calls of this species are very similar to those of the common loon but are uttered more slowly in at least some cases and are pitched about half an octave lower. They identified eight calls, including three variations of yodeling. Typical yodeling consists of a prolonged series of calls lasting up to about 2 seconds, with sudden breaks between tones. This call may be heard for more than 8 kilometers. In 5 ascertained cases the call was uttered by a resident male. A variation of yodeling is "short yodeling," in which the call stops after the first break, and another variation is "choked yodeling," in which the call is uttered by a bird in the "fencing posture"; apparently because of the posture the sound quality is also altered. The tremolo call, equivalent to the "laughing" note of the common loon, is similar to the call of that species but is lower in pitch and slower. In most cases it is uttered antiphonally between pairs, with the male's voice distinctly lower in pitch than the female's. Wailing is similar to yodeling but is a wolflike howl that lacks sharp breaks and remains on almost the same pitch, with a slight rise in the middle of the call. Moaning is similar to human moaning, but when performed at higher intensities a break to a higher note occurs in the middle. Moaning is performed by both sexes. The minor calls include a weak and low-pitched call that can be heard only fairly close by and a chirping note uttered by young birds.

Sjolander and Agren (1976) regarded the low call and moaning as contact calls between pairs, wailing and the various forms of yodeling as territorial calls, the tremolo as an alarm call, and chirping as a juvenile contact call that may be the ontogenetic precursor to yodeling and wailing.

Displays of the species have also been described and illustrated by Sjolander and Agren (1976); the postures appear to be virtually identical to those of common loons and thus are not illustrated here. Neck stretching ("raised neck") is performed by both sexes, with the bill pointed obliquely upward. In a slightly less neck stretched ("high front") position the forehead feathers are sometimes raised in a distinct bulge. The tremolo vocalization often accompanies this posture. In a "short neck" posture the bill is held downward, hiding the throat. This posture is performed by females, though males sometimes were seen in a similar posture when searching for nest sites. Bill dipping often occurs during neck stretching or the high front posture and is performed by both sexes in a manner more rapid than normal peering behavior. Both sexes may also perform "mock sleeping" with the bill under the wing feathers but the eyes open. Conspicuous, high-intensity aggressive displays include rushing, fencing, and bow jump-



ing. During rushing the bird half flies, half runs over the water for as much as 450 meters. It is performed by both sexes, most often when an individual is within a meter of another bird. During fencing the bird rises almost vertically and treads water, with its bill held close to the breast and the wings either folded or extended. The bird may remain almost stationary in this posture or may even leap out of the water occasionally. While leaping, the head is moved forward and backward, and the movements may become elaborated into bow jumping, which is an alternation of fencing and bill dipping postures. Fencing or bow jumping are apparently typically performed by resident males and by males with young. Splash diving, done by both sexes, is a loud splashing dive, sometimes performed after rushing or fencing. Both sexes also perform jerk swimming, a repeated forward and backward movement of the head, especially as two birds approach each other. Finally, females perform search swimming while swimming along the shoreline in a short neck posture, or they may go ashore and lie down in the short neck posture while searching for suitable nest sites.

Sjolander and Agren (1976) regarded neck stretching as a general arousal signal, such as when the bird is frightened, the high front posture as similar but more aggressive, and both bill dipping and splash diving as indicating excitement or alarm. Fencing, bow jumping, and rushing are all essentially associated with territorial defense and are basically aggressive in motivation rather than related to pair formation or copulation.

The only behaviors consistently shown in connection with copulation are mutual jerk swimming and, immediately before copulation, search swimming and going ashore. The female typically goes ashore and may make nest building movements with her bill. The male typically follows the female, mounts her, and copulates for 9 to 12 seconds (2 observed cases). He then dismounts and returns to the water, while the female may remain ashore for several minutes (Sjolander and Agren 1976).

## Reproductive Biology

**BREEDING SEASON AND NESTING SUBSTRATE.** In arctic Canada and Alaska the breeding season is fairly late and compressed. Sage (1971) judged that the eggs he found in northern Alaska had been laid during the first half of June, and Parmelee, Stephens, and Schmidt (1967) found one nest on Victoria Island in 1960 that they believed had been incubated since June 25 and probably begun by June 22. In 1962 another clutch was found that had probably been laid about June 20. Incubation in one apparent renesting effort had probably begun about July 3.

The eggs of 6 pairs of loons studied by Sjolander and Agren (1976) in northern Alaska hatched between July 18 and 21, suggesting that they must have been laid shortly after the middle of June. Bailey (1948) reported on 22 clutches obtained in the vicinity of Barrow, Alaska, between June 15 and July 8. All of these dates suggest that egg laying is probably confined to the period between mid-June and early July.

As in other loons, the nest is at the water's edge, either along the perimeter of a water area or on an island. The nests are typically in turf from which the grass cover has often been removed; they may be up to about 6 feet from water but usually are within a foot or so of the water's edge. All of 10 nests found by Sjolander and Agren (1976) were within 2 meters of shore and within a meter above the water, and most were at the very edge of water. Three were on small islets, 2 were on small peninsulas, and the other 5 were on the shorelines of lakes lacking islands or peninsulas.

**NEST BUILDING AND EGG LAYING.** No specific information is available on nest-building behavior or the length of time required to complete a nest. The eggs are probably laid 2 days apart, based on the staggered period of hatching. Virtually all reported clutches of this species are of 2 eggs.

**INCUBATION AND BROODING.** Both sexes incubate the eggs, for periods that range from as little as 220 seconds to at least 14 hours, based on the observations of Sjolander and Agren (1976). They also noted that the eggs were turned at irregular intervals of from 12 seconds to more than 6 hours. The incubating bird sits with its head toward the water and may sleep for short periods without tucking the bill under the scapulars. The birds never called while on the nest and never allowed a human within 40 meters of the nest before leaving it. The incubation period has not been established, but it is likely to be similar to the 29–30 day period known for the common loon. Sjolander and Agren (1976) judged that it might be 27 to 29 days.

As noted earlier, one case of renesting has been reported (Parmelee, Stephens, and Schmidt 1967), involving a pair whose clutch was collected on June 30 and had been incubated an estimated 5 days. Successful renesting occurred, and the date of hatching of this second nest (by August 1) indicated that incubation of the second clutch must have begun no later than July 4, only 4 days after the first clutch was collected, unless the incubation period of this species is shorter than that of the common loon. On the other hand, Sage (1971) observed that no replacement clutch was laid by a pair after nest losses to predators in early July during two separate years. The eggs of 6 pairs of loons observed by

Sjolander and Agren (1976) all hatched between July 18 and 21, suggesting a highly synchronized breeding period in that area.

**GROWTH AND SURVIVAL OF YOUNG.** The chicks hatch asynchronously, about 2 days apart. The eggshells are evidently removed from the nest, and during the first 3 days after hatching the young are evidently brooded ashore, either at the nest or close to it. After 9 days the young are brooded under the parents' wings or on their backs as the adults are swimming. For the first 12 days the young remain within about 2 meters of the nearest parent, but gradually this distance increases to at least 30 meters. Both parents feed their chicks, with fish 4–6 centimeters long and also at least some plant materials. Feeding of the young continues until the young are at least 35 days old and probably longer, judging from the account of Sjolander and Agren (1976). Although these authors stated that all food was captured at the nesting lake, Sage (1971) saw breeding adults flying to other lakes to forage. By the time the young are 30 days old they are able to swim at least 40 meters underwater. As in the other species of loons, one of the two chicks often is lost during the first few days of life, though the reasons for this are still uncertain. The fledging period is still unreported.

**BREEDING SUCCESS AND RECRUITMENT RATES.** No data on these topics are yet available.

## **Evolutionary History and Relationships**

Certainly the yellow-billed loon and common loon are extremely close relatives, based on both morphology and behavior. Sjolander and Agren (1976) found no major differences in reproductive or territorial behavior between these two forms and supported the idea that they should be considered subspecies. This position has been frequently taken by Soviet ornithologists (e.g., Portenko 1981; Dementiev and Gladkov 1968). However, there is an absence of intermediate connecting forms in both Asia and North America, which seems to justify continued species-level separation. The yellow-billed loon may well be a Pleistocene disjunct population that originated in the vicinity of the Bering Sea and has become adapted to high arctic breeding, keeping it ecologically isolated from the more subarctic-adapted common loon.

## **Population Status and Conservation**

So little is known of this species' population size that not much can be said of conservation needs. It both breeds and winters well away from most human contacts, and except for the unlikely possibility of major oil spills or other habitat destruction on major wintering or migratory routes, little current concern seems justified. It has been assigned an oil vulnerability index of 65 by King and Sanger (1979).